AN ECOLOGICAL SURVEY

OF

ISLE ROYALE, LAKE SUPERIOR

PREPARED UNDER THE DIRECTION OF

CHAS. C. ADAMS.

A Report from the University of Michigan Museum, published by the State Biological Survey, as a part of the Report of the Board of the Geological Survey for 1908.

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LETTER OF TRANSMITTAL.

To the Honorable the Board of Geological Survey of the State of Michigan:

Gov. Fred M. Warner, President.
Hon. D. M. Ferry, Jr., Vice-President.
Hon. L. L. Wright, Secretary.

Gentlemen:—I beg to present herewith for printing, a report by Dr. Chas. C. Adams on the ecology, that is the natural history, of Isle Royale. This comes to us with the approval of Dr. A. G. Ruthven, our Chief Field Naturalist, and our Board of Scientific Advisers, and is a continuation of the work published in our annual report for 1905.

This contribution to the Biological Survey of the State, which the legislature authorized me to supervise by Act No. 250 of the session of 1905, comes from the University Museum. The explorations were made without expense to the State Survey by means of contributions from friends of the Museum. As this work is in harmony with the aims of the Biological Survey we are fortunate in securing such co-operation. The reports on the Porcupine Mountains and Isle Royale at the north end of the state complement the work on Walnut Lake, Oakland county, and that in Huron and Tuscola counties.

I trust that the present report will be of service to the schools of the state.

Very respectfully,
ALFRED C. LANE,
State Geologist.

ILLUSTRATIONS.

PART II. ANNOTATED LISTS.

INTRODUCTORY NOTE.

Through the generosity of Mr. Bryant Walker, of Detroit, Hon. Peter White* and Mr. H. M. Kaufman of Marquette, the University Museum of the University of Michigan was able, in the summer of 1904, to send a party to the Porcupine Mountains and to Isle Royale, Michigan. The aim of the party was to collect specimens for the museum and to make an ecological survey of the regions visited. The party was only able to spend a few weeks on Isle Royale at that time, but through the continued generosity of Mr. White and Mr. Walker, the survey was continued during the summer of 1905. The present volume on the natural history of the island has resulted from these surveys.

To Mr. White and Mr. Walker the Museum is under special obligations for their hearty and substantial support, not only in the funds provided, but also for their aid in securing the transportation of the party. Many other individuals also assisted in various ways. Those who aided the party in the matter of transportation were: Mr. Henry Russel, of the Michigan Central Railway; Mr. Geo. T. Arnold, of the Union Ticket Office and Dock of Mackinac Island; Mr. H. H. Brigham, of the U. S. and Dominion Transportation Company ("Booth Line"); Mr. Henry Meyering, of the Graham and Morton Line; Mr. M. Adson, of the Duluth, South Shore and Atlantic Railway. The survey is furthermore indebted to Section Director C. F. Schneider of the Michigan Section of the Climatological Service of the U. S. Weather Bureau, for the loan of meteorological instruments; to Major Lansing H. Beach, Detroit, of the Light House Establishment, for permission and suggestions as to camping in the abandoned Light-house at Rock Harbor; to Mr. Geo. C. Stone, Secretary of the Washington Club of Duluth, Minn., for the use of their grounds and many favors from their care-takers, Mr. Chas. Preulx and Mr. Michael Hollinger; to Mr. K. Neutson, of Park Place ("Neutson's Resort"), Rock Harbor, Isle Royale, for many favors during the stay upon the island; to Mr. J. H. Malone, Keeper of the Isle Royale Light, and to his sons, particularly to the Assistant Keeper, Mr. J. A. Malone, for many favors and for their hospitality. It is a pleasure to have this opportunity of thanking these persons for their cooperation.

On the return of the party from the field, work was at once begun upon the collections, and in this a large number of specialists have aided by the determination of the specimens. Acknowledgements are made to such persons throughout the report and will not be repeated here. Those who were not members of the party, but who have prepared papers are: Mr. Bryant Walker, of Detroit, Michigan, Dr. W. M. Wheeler, American Museum of Natural History; Mr. A. P. Morse, Research Assistant of the Carnegie Institution, and Wellesley College; Dr. Jas. G. Needham, Cor-

* Recently deceased.

nell University; Prof. J. S. Hine, Ohio State University; Prof. E. S. Titus, Utah Agricultural Experiment Station; Dr. A. G. Ruthven, University Museum, University of Michigan, and Mr. A. B. Wolcott, Field Museum of Natural History.

The volunteer members of the Museum party should be mentioned in this connection: Dr. R. A. Brown, Dr. H. A. Gleason, Mr. W. P. Holt, Mr. Max Minor Peet, Mr. Otto McCreary, and the writer. It will be evident that the volunteer work of this report comprises the major part of it.

Personally the writer wishes to express his appreciation of the assistance of Mr. Walker and Mr. White; of the cooperation of the members of the party and the many specialists who have examined the specimens; and of the valuable suggestions and assistance of: Mr. Norman B. Conger, Inspector U. S. Weather Bureau, Detroit; Dr. Glover M. Allen, Boston Society of Natural History; Mr. Frank Leverett and Mr. F. B. Taylor. of the U. S. Geological Survey; Prof. H. F. Wickham, State University of Iowa; and to Mr. A. B. Wolcott, of the Field Museum of Natural History. Also to Dr. A. C. Lane of the Michigan Geological Survey for many favors and courtesies, including the preparation of the topographic map, and to Dr. A. G. Ruthven, Chief Field Naturalist of the Survey, for assistance in the publication of the report.

The shortcomings of this report will be no more evident to any one than to the writer. If, however, with its defects, it preserves some "vanishing data," and presents suggestions for the improvement of such ecological surveys, it will have served the purpose for which it was intended.

CHAS. C. ADAMS.

July 23, 1908.
Hull Zoological Laboratory,
University of Chicago.

ERRATA ISLE ROYALE REPORT.

Page 2, line 29, for *and the* read *for the.*
Page 5, line 30, for *sources* read *resources.*
Page 11, line 43, for *larger* read *large.*
Page 13, line 11, for *White Spruce* read *Black Spruce.*
Page 14, line 7, for *has been* read *had been.*
Page 15, line 16, for *Cicada* read *Tibicem.*
Page 16, line 40, for *anti-lion* read *ant-lion.*
Page 19, line 28, for *hardwood* read *hardwoods.*
Page 21, line 24, for *Hibbiscus* read *Hippiscus* (and elsewhere in the report).
Page 21, line 25, for *versicolor* read *pickeringi.*
Page 21, line 48, for *Limnaea* read *Lymnaea* (and elsewhere in the report).
Page 22, line 26, for *2F* read *26.*
Page 22, line 43, for *Aechna* read *Aeschna.*
Page 26, line 21, for *Grophaena* read *Gyrophaena.*
Page 27, line 2, for *billow* read *billowy.*
Page 29, line 14, for *Fig. 45* read *Figs. 45 and 57.*
Page 46, line 21, for *the bearing of the latter* read *their.*
Page 47, line 46, for *e* read *4.*
Page 48. line 14, for *Fig. 53* read *Fig. 55.*
Page 50, line 33, for *f* read *5.*
Page 61, line 28, dele (*Fig. 29*).
Page 63, line 10, dele *Fig. 30.*
Page 63, line 16, for *Lake* read *Lakes.*
Page 64, line 3, for *Fig. 22* read *Fig. 26.*
Page 65, lines 48 and 49, for *Formica adamsii* read *Formica adamsi.*
Page 65, lines 50 and 51, dele *No. 114.*
Page 77, line 27, for *Grophoena* read *Gyrophaena.*
Page 93, line 25, for *XI* read *VI.*
Page 110, line 6, for *condition of weather* read *condition of sky.*
Page 135, line 31, for *fostered* read *forested.*
Page 152, line 29, for *Burns, F. Z.* read *Burns, F. L.*
Page 158, line 43, transpose *Buprestids* and *Trichias.*
Page 159, line 9, for *Grophoema* read *Gyrophaena.*
Page 161, line 44, for *Their* read *their.*
Page 188, line 28, dele *William.*
Page 205, line 46, for *Bolitobius* read *Boletobius.*
Page 205, line 46, for *Ney Jersey* read *New Jersey.*
Page 257, line 17, read *Salticidae=Attidae.*
Page 261, line 43, for *Jassidaeae* read *Jassidae.*
Page 284, line 28, for *61-62* read *Figs. 61-62.*
Page 306, line 26, dele *S.*
Page 306, line 28, add *S.*
Page 306, line 29, add *S. elongata.*
Page 342, line 25, for *Fig. 45* read *Fig. 57.*
Page 350, line 35, add *Fig. 60.*
Page 354, line 17, add *Fig. 17*; line 20, dele *Fig. 17.*
Page 393, line 15, for *influences* read *inferences.*
Page 397, line 7, for *Canton* read *Caton.*
Page 407, line 26, for *J. N. Malone* read *J. H. Malone.*
Page 419, line 14, for *Hoops* read *Hoopes.*

B

ISLE ROYALE AS A BIOTIC ENVIRONMENT.

BY DR. CHARLES C. ADAMS.

I. INTRODUCTION.

1. *Itinerary and Personnel of the Party.* The University Museum party left Ann Arbor, Michigan, June 29, and reached the abandoned light-house at Rock Harbor, Isle Royale, on the morning of July 5, 1905. The party was composed of the following: N. A. Wood, Dr. R. A. Brown, Dr. H. A. Gleason, W. P. Holt, Otto McCreary, a camp hand, B. F. Savery, and the writer. In general, the duties of the various members were as follows: Mr. Wood, the Museum taxidermist, looked after the trapping of mammals and the preparation of bird and mammal skins. He was assisted by Dr. Brown, who gave most of his attention to the study of the bird life, and who remained with the party until July 25. In the study of bird life, Dr. Brown, Mr. Wood and Mr. McCreary co-operated, the latter devoting his entire time to the ecological phase of the work. Dr. Gleason devoted his attention to the collection and ecological study of invertebrates, particularly molluscs and insects, and most of the photographs were taken by him. In collecting insects about the camps, he was assisted by B. F. Savery. Mr. Holt's time was devoted to the study of the vegetation. The writer, who was in charge of the expedition, gave special attention to the environmental dynamics, biotic succession, and the general correlation of the work of the various members of the party.

During the stay at Rock Harbor, *Fig. 1*, the following localities were examined: The shore, from the light-house south to the head of Conglomerate Bay; the region about the head of Rock Harbor and Summer lake; a line from the mouth of Benson brook to Sargent Lake and McCargoe Cove.; and the vicinity of Tobin Harbor; in other words, the localities included in Stations I-IV.

The party remained at Rock Harbor from July 5 to August 1, and then moved to Siskowit Bay. Here Mr. Max M. Peet joined the party on August 8, and devoted his attention to collecting birds and mammals. He also took a number of the photographs. While at the Siskowit Camp, the bay and lake of that name were examined, and also the Haytown trail and the islands near the Isle Royale Light. All of these localities are included in Station V.

On August 17 the party moved to Washington Harbor, and was then partially disbanded. The members who remained made their headquarters on the grounds of the Washington Club, at the head of Washington Harbor. After September 5 Mr. Peet alone remained there until the 22nd, in order that he might continue the study of the fall migration

of the birds. He returned on the last boat of the season for Duluth, Minn.

During the previous (1904) season, the Museum party had made a general examination of the vicinity about Washington Harbor, so that it was now thought desirable to devote more time to other localities. With the exception of bird migration, no detailed work was done in this vicinity in 1905. In addition to the region about the head of the harbor, Lake Desor was also reached from this point by means of the road along the crest of the Greenstone Range.

2. *The Aim and Methods of Work.* The field work was conducted on the same general plan as that pursued during the previous season in the Porcupine Mountains and at Washington Harbor. Much more ground was covered, however, because it seemed improbable that a third trip could be made to the same region. It therefore seemed desirable to gain some idea of the biota of the island as a whole, because of its Canadian character. Even then, the survey was confined almost exclusively to the region south of the Greenstone Range.

As mentioned in the report for 1904 (Ruthven, '06, pp. 11-12), the aim of the work was not simply to collect specimens, but also to study the relations of the plant and animal life (the biota) to their surroundings. The environment as well as the biota was considered from a dynamic standpoint, and an effort was made to analyze the environment in order that the dominant conditions and processes of which it is composed might be recognized, and their laws of change be perceived and formulated. To resolve such a problem as this must of necessity require more time and detailed investigation than the possibilities of a few months work will permit, and yet it is equally evident that preliminary work should be carried on from a genetic standpoint, because such a method determines upon what facts emphasis should be placed, and the broader and more general relations, as well as the details, are equally subject to a genetic and dynamic treatment. In preliminary work of this character, it is considered of special importance to discover, if possible, the order of the major biotic successions, because these successions must be clearly perceived before their causes can undergo adequate analysis. Our knowledge of causes generally lags far behind our recognition of successions.

Thus throughout the study of the Isle Royale biota a special effort was made to investigate the genesis or successions of events. The environment has not been considered as limited to habitats alone, but also to include that greater unit, the geographic. To ignore this is to overlook the real background. It is believed that certain advantages are derived from this method of work, which, although they may be recognized from other points of view, are likely to be subordinated to other facts. It should not for a moment be thought that this method is considered as the only one of approach, but it appears to have certain advantages which seem to justify its adoption. Nor should it be inferred that the genesis of the biota and the habitat is all that should be included in an ecological survey. The problem of succession is only one of several which clearly show the intimate relations and responses between organisms and their environment; others that remain to be investigated involve physiological and structural changes, and various modifications of habit and behavior of both plants and animals.

The ecological relations in the north are so different, in some respects, from those farther south, that one may easily form an erroneous conception of the conditions under which such a preliminary investigation may be made. A very favorable condition for the work was the fact that practically all the time was devoted to it, instead of only occasional trips being made for the purpose, as is necessary with those busy with other duties. There are also certain advantages in being able to be in the field continuously, as a certain familiarity with conditions is acquired in the beginning, especially where the variety of forms is limited, which otherwise would involve time upon each visit. Although most of the members of our party were upon the island only during July and August, yet at this time those seasonal phenomena were concentrated which require much more, or several times that amount of time for their development farther south. The seasonal contrast is well illustrated when the summer season at the other extreme of the State of Michigan—500 miles away—is contrasted with that of Isle Royale. Such relations are further reinforced by the fact that the species and societies which are dominant in the various northern habitats are very much smaller in number than farther south. This necessarily simplifies the problem, and to a corresponding degree reduces the chances of error in anticipating biotic changes which are correlated with those of the environment. This is a relation of much importance in the study of succession. The writer was especially impressed with the *relative simplicity* of the problem of environmental relations and of the biotic succession upon Isle Royale, and has received further confirmation of the opinion that a tendency to exaggerate the complexity of the environment is prevalent.

An important aid in environmental analysis has been received from the effort to distinguish the major or geographic features of the gross environment from the minor habitat units which make up the mosaic or complex, although their mutual and genetic relations were not overlooked. Some of these relations have been well expressed by Montgomery in his comment on distribution ('06, p. 6) as follows: "And, as is always the case when the method has been consistent and scientific, the factors of distribution and the meaning of it will ultimately be stated in very simple form. These factors appear to us now to be enormously complex, but this is because we have hardly commenced to analyze them."

At this point it should be mentioned that there are certain difficulties which tend to confuse the field worker, which, if clearly understood, will often be of aid in ecological studies. In pursuing field studies, in addition to a knowledge of the species, one of the first essentials is a familiarity with the habits and habitat preferences of organisms; and further, there should be the ability to recognize how the dominance of one society is transformed into that of another. The lack of a sufficient power of constructive imagination makes the detection of such transformations very difficult, perhaps even impossible to some. This limitation almost completely restricts such a student to the purely descriptive phases of field ecology, because the explanatory phase lies beyond his grasp, although there remains for him a large

field for useful and valuable activity in the study of habitat preference, and the mutual relations of the associated species in given habitats. A familiarity with the forms studied, under diverse circumstances, develops a certain perspective which is a great help in preventing confusion caused by minor and relatively insignificant details.

The limited time spent in the present investigation did not permit detailed studies of the interrelations of the organisms within the habitat, either in their relation to the environment or to each other. In local studies attention is usually given to detailed life histories rather than to a deliberate study of their interrelations as members of a society. The emphasis which is sometimes placed upon individual life histories would lead one to expect that such histories could be assembled and would give us the same result as if they had been studied as a *society*. But the points of view are so different that such a result, although theoretically possible, is unlikely to be obtained. At this time we only wish to emphasize the fact that both methods should be used to secure the best results. For example, in applying these principles to the study of birds, the life histories of the *dominant* species of a society might first be given special attention. Then the relations of the *dominant* species to others of the association and to the environment may be determined and later on the subordinate kinds considered. This will involve prolonged study in the field (and laboratory) of the habits of nesting, feeding, rearing of young, etc., as influenced not only by other members of the same species, but also by other species in the same habitat. The same general method is applicable to other groups of organisms.

3. *Previous Biological Investigations upon Isle Royale.* Previous to the investigations by the Museum party in 1904, (Ruthven and others, '06) there seems to have been very little study of the Isle Royale biota. Several collections of plants and animals have been made, but very little has been published about them. In 1848 W. D. Whitney was "ornithologist and botanist" for the government geological survey parties, and he published a list of the plants found. (Foster and Whitney, '51, pp. 359-381). Incidental mention is also made in these geological reports of the collections of animals (Foster and Whitney, '50, pp. 17, 51, 201; Jackson, '49. pp. 423, 440, 441,) ; but, so far as known to the writer, no detailed reports were published.

So far as the vegetation is concerned, the most important source of information is the maps of the Ives Linear Survey. Here the general character of the forest, the extent of the swamps, and the underbrush are indicated. Mr. Henry Gilman ('73), of Detroit, made two visits to the island (one of which was in 1873), and his botanical and ethnological collections were presented to Columbia and Harvard Colleges. In 1890 Mr. F. E. Wood made a collection of plants from the vicinity of Rock Harbor and presented them to the herbarium of the Botanical Department of the University of Michigan; and in 1901 W. A. Wheeler ('01) published a short paper on some plants taken on the northeast end of the island.

The invertebrate fauna found in the deep water off Isle Royale was examined by Smith in 1871, and a list of Coleoptera from Isle Royale was published by Hubbard and Schwarz ('78). The writer has recently published a paper on certain phases of the problem of succession, as

illustrated by the birds upon Isle Royale. This paper, with some additions, is included in this volume. Detailed references to these papers will be found in the accompanying bibliographies.

From the above remarks, is it quite evident that very little attention has been given to the biological conditions of the island, and much remains to be done. In all probability other naturalists have visited the Isle, but I have not learned of their results.

4. *Historical Note.* The history of Isle Royale, since its cession by the Chippewa Indians in 1843, is, in brief, one of prospecting, mining explorations, fishing, summer resorts, and scientific surveys of the topography, hydrology, geology, and biology.

A general historical account is given in Lane's report ('98) on the geology of the island, and need be mentioned here only in outline. There is abundant evidence that in prehistoric times the Indians mined copper on the island. Within three or four years after the cession of the island to the United States, it was invaded by prospectors and explorers, so that by 1847, according to Lane, "the island presented perhaps as lively a scene as ever in its history." At this time the Linear Survey was made by William Ives. But this period of activity was only of short duration, for the decline was almost as rapid as had been the ascent, and by 1855 the "island was a desert once more, with no permanent inhabitants." (Lane). This passive condition of affairs lasted until the Lake Survey engineers arrived in 1867. This survey continued until 1871, during which interval explorations were somewhat revived, and continued for several years, only to be followed by another relapse and still another ascent in 1891, when a number of careful and detailed explorations were made for copper by means of the diamond drill. But this activity also ceased about 1892. A year later, and again in 1895, Dr. Lane visited the island for geological investigations.

The mineral sources are thus seen to have been the main attraction. The forest growth is too stunted and inaccessible to have merited the attention of lumbermen, although several timber prospectors were present during the summer of 1905. During more recent years the fishing and summer resort business have attracted some attention to the island, and have made it accessible during the summer through regular steamboat service. The climate, scenery and the fishing make the island very attractive as a summer resort, but it should be recognized that if the scenery is to be preserved the forests must be protected from fires, because reforestation is exceedingly slow on land with such a shallow soil. It is to be hoped that the geographic isolation may be a protection from such devastation, because the cool summer climate, the rocky coast, the forests, the picturesque scenery, and the surrounding Lake Superior, are natural features which should long remain attractive to summer visitors. If the interest in copper should revive permanently, the biota will become greatly modified, in which case some conception of the conditions upon the island in 1904 and 1905 will be preserved by these records.

[It may be of interest to note here that 86,000 acres of the island were for sale in the winter of 1908 for $150,000. Lane.]

5. *Available Maps of Isle Royale.* The available maps are not generally known to the public, and are therefore listed here, especially those which are of value from a biological standpoint.

1. The Ives Linear Survey Maps. Because of their large size (2 inches to the mile), and the details concerning the character of the swamps, the forest and the soil, this is the most useful map for the field. Photolithographic copies of the township maps, of which there are eighteen, may be secured for 25 cents each from the General Land Office at Washington, D. C.

2. The U. S. Lake Survey Chart of Isle Royale, (Catalog No. Sh.). This is very useful because it indicates the topography, in part by hachures, and gives the details of the coast, including soundings and the character of the bottom. A large tract of the interior, between lakes Desor and Chickenbone, is unmapped. This map may be secured for 25 cents from the Lake Survey Offices at Detroit and Duluth. An excellent chart of the entire Lake Superior basin may be secured from the same source.

3. Lane's Geological Map. Published by the Michigan State Geological Survey. It accompanies Lane's report ('98) on the geology of the island, and is on a scale of 5/8 of an inch to the mile.

4. Passage Island Topographic Sheet. This is the only sheet published by the U. S. Geological Survey which includes any part of Isle Royale, and it covers only the extreme northeastern end of the island. This may be secured from the Survey for 5 cents. The contour interval is 20 feet, and the scale one inch to the mile.

5. An English land company is said to own much of the island, and has published a map on a scale of 7/8 of an inch to the mile. The agent for this company is R. R. Goodell, Houghton, Michigan.

II. THE BIOTA CONSIDERED BY STATIONS.

1. *The Location of Field Stations in 1905.* As a detailed survey of the entire island was impossible, it was necessary to select representative localities and conditions, or habitats, and to devote to these all available time for study and collecting. In order to make sure that these conditions were representative, considerable care was necessary in locating these stations. In general a Station, in the strict sense, stands for a region, while a Substation refers to a particular habitat, usually of relatively limited extent. The character and extent of a Substation, (or, as it is generally called, for the sake of brevity, a "station,") was determined primarily by the relatively homogeneous character of the conditions. Thus a "station," as the Balsam-Spruce forest (V, 4) for example, varied somewhat in its extent with different groups of organisms. In the case of birds it included a greater area than was necessary for many invertebrates, such as land snails, but in every case such a "station" is intended to enable one to determine what organisms were dominant and characteristic of such a sample situation.

Some such system of sampling is generally advantageous or necessary, and this is particularly essential in the case of a surveying party, in order to give definiteness and co-ordinated activity to their work, particularly if the results are to be made at all comparable. Of course some individual judgment is necessary in applying such a plan to different groups, but no more perhaps than is necessary to carry out any other comprehensive plan.

1. Location of Field Stations, 1905.

Station I. Light-house Peninsula, between Rock Harbor and the head of Conglomerate Bay, Sec. 26 and N. E. ¼ Sec. 34, T. 66 N., R. 34 W.

Sub. 1. Lake and Bay Beaches.
Sub. 2. Natural Rock Clearings, N. E. ¼ Sec. 26.
Sub. 3. Balsam-Spruce Forest, N. E. ¼ Sec. 26.
Sub. 4. Tamarack, and Arbor Vitae Swamps, Sec. 26.
Sub. 5. Jack Pine Ridge, S. W. ¼ Sec. 26 and S. E. ¼ Sec. 27.
Sub. 6. Sphagnum-Spruce Bog, S. W. ¼ Sec. 26 and S. E. ¼ Sec. 27.
Sub. 7. Light-house Clearing, N. W. ¼ Sec. 26.

Station II. Rock Harbor and McCargoe Cove Trail, Sec. 27, 22, 21, 20, 29, 30, T. 66 N., R. 34 W., and Sec. 25 and 26, R. 35 W., T. 66 N.

Sub. 1. Benson Brook and Ransom Clearing (outlet of Benson Lake), N. E. ¼ Sec. 27 and S. E. ¼ Sec. 22, T. 66 N., R. 34 W.
Sub. 2. Tamarack Swamp, S. W. ¼ Sec. 22 and S. E. ¼ Sec. 21, T. 66 N., R. 34 W.
Sub. 3. Rock Ridge Clearings (burned over). Sec. 21 and 20, T. 66 N., R. 34 W.
Sub. 4. McCargoe Cove, at end of Trail. N. E. ¼ Sec. 26, T. 66 N., R. 35 W.
Sub. 5. Forbes Lake, N. E. ¼ Sec. 28. T. 66 N., R. 34 W.

Station III. Western End of Rock Harbor, Sec. 28, 33 and 32, T. 66 N., R. 34 W., and Sec. 5 and 4, T. 65 N., R. 34 W.

Sub. 1. Small Island, S. E. ¼ Sec. 32.
Sub. 2. In Harbor at West end of Island, Sub. 1.
Sub. 3. Bulrush Zone and Delta, Sec. 32, T. 66 N., R. 34 W.
Sub. 4. Trail to Sumner Lake, Sec. 33, T. 66 N., R. 34 W.
Sub. 5. Sumner Lake, Sec. 33 and 34, T. 66 N., R. 34 W.
Sub. 6. Southwest Coves of Rock Harbor, Sec. 5 and 4, T. 65 N., R. 34 W.

Station IV. Tobin Harbor and Vicinity, T. 66 and 67 N., R. 33 W.

Sub. 1. Scovill Point, Sec. 26 and 35, T. 67 N., R. 33 W.
Sub. 2. Island No. 14, Sec. 26, T. 67 N., R. 33 W.
Sub. 3. Bayou, North of Monument Rock Trail, N. W. ¼ Sec. 34, T. 67 N., R. 33 W.
Sub. 4. Trail to Monument Rock, N. W. ¼ Sec. 34, T. 67 N., R. 33 W.
Sub. 5. Clearing at Neutson's Resort (Park Place), Sec. 4, T. 66 N., R. 33 W.
Sub. 6. Small island in Tobin Harbor, Sec. 5, T. 66 N., R. 33 W.
Sub. 7. Head of Tobin Harbor, Sec. 7, T. 66 N., R. 33 W.
Sub. 8. Trail to Greenstone Range, Sec. 7, T. 66 N., R. 33 W., and Sec. 12, T. 66 N., R. 34 W.
Sub. 9. Mountain Top, Sec. 12, T. 66 N., R. 34 W.

Station V. Siskowit Bay, Lake and Vicinity.

Sub. 1. The Beach, (at camp), Sec. 32, T. 65 N., R. 35 W.
Sub. 2. Heath Zone and Beach, Sec. 33, T. 65 N., R. 35 W.
Sub. 3. Rock Clearing (at camp). Sec. 32, T. 65 N., R. 35 W.

Sub. 4. Trail through Balsam-Birch Forest, Sec. 32 and 31, T. 65 N., R. 35 W.

Sub. 5. Tamarack Swamp. N. W. ¼ Sec. 32, T. 65 N., R. 35 W.

Sub. 6. South Shore of Siskowit Lake, Sec. 31 and 32, T. 65 N., R. 35 W.

Sub. 7. Haytown Trail, from Siskowit Lake, West Line of Sec. 24, across Sec. 13, T. 65 N., R. 36 W., cf. Lane, '98, pl. XI.

Sub. 8. Arbor Vitae Swamp, at end of Haytown Trail, N. W. ¼ Sec. 13, T. 65 N., R. 36 W.

Sub. 9. Outlet of Siskowit Lake, N. W. ¼ Sec. 36, T. 65 N., R. 36 W., and Sec. 31, T. 65 N., R. 35 W.

Sub. 10. Long Island Gull Rookery and Menagerie Island, T. 64 N., R. 33 W.

Sub. 11. Tamarack-Spruce Swamp, Sec. 33, T. 65 N., R. 35 W.

The following stations were examined by the Museum party during the season of 1904. Part of these Stations were re-examined and will be referred to by Station number and date, thus: Sta. I, '04.

Station I, '04. Clearing on the Shore of Washington Harbor, Sec. 29, T. 64 N., R. 38 W.

Station II, '04. Washington Creek, Sec. 29, T. 64 N., R. 38 W.

Station III, '04. Trail along the top of Greenstone Range (Desor Trail), T. 64 N., R. 37, 38 W.

Station IV, '04. Washington Brook, Secs. 28 and 32, T. 64 N., R. 38 W.

Station V, '04. Tamarack Swamp, Sec. 20, T. 64 N., R. 38 W.

Station VI, '04. South of Greenstone Range, Sec. 32, T. 64 N., R. 38 W.

Station VII, '04. Lake Desor, T. 64 N., R. 32 W.

Station VIII, '04. Western end of Siskowit Bay, Secs. 27 and 28, T. 64 N., R. 37 W.

Station IX, '04. Southwestern end of Minong Trap Range, Sec. 30, T. 64 N., R. 39 W.

Station X, '04. Washington Harbor, T. 64 N., R. 38 W.

2. General Characteristics of the Stations. In this section, I do not aim to give a completely correlated account of the biota of each station, but to present a general idea of the main characteristics of the various situations examined, and some of their common and representative plants and animals. Photographs illustrating the characteristics of the various "stations" will accompany this section, and should be consulted in connection with the text.

Station I, Substation 1. The Lake and Bay Beaches. This "station" includes the shore line from Rock Harbor, near the light-house, *Fig. 1*, to the head of Conglomerate Bay. The entire shore was not studied in detail, as most of the time was devoted to the beaches which are being formed at the heads of the coves and bays. Quite a variety of conditions are represented along this shore, due not only to the degree of exposure to the waves of Lake Superior, but also to the character of the rocky coast itself. All degrees of shore and beach are developed, from overhanging and vertical cliffs, *Fig. 2*, with bases strewn with large blocks lowered by sapping, to a shore line with a low angle strewn with shingle and gravel, and a sandy beach, as found at the head of Conglomerate Bay. In harmony with the dip of the rocks and the effect of the

glacial ice movement upon the valley slopes, which tend to be gentle on the southeastern side, the corresponding shores of the bays and coves are usually at a low angle, except possibly where faulting has taken place, or a wave cut terrace has been developed. The northern sides of the bays are comparatively abrupt, and there is thus a tendency for the cliffs to occur mainly upon the northern slopes and shores. The larger bays are the submerged portions of the valleys, mark the location of the less resistant rocks, and are inherited topographic features; but many of the minor coves and the rocky headlands have been carved by the activity of the present lake. The beaches are only developed at the heads of the coves and bays, and are very largely composed of shingle and gravel. The only extensive sand beach seen was at the head of Conglomerate Bay. The character of the material composing these beaches clearly shows its local origin, and emphasizes the isolation which prevents long shore transportation of such material. Thus only floating material is liable to extensive long shore dispersal, a significant fact that bears upon the dispersal of the snail life along the shore.

During severe storms, the wave action upon this coast is quite intense and even the waves of the summer storms are quite active, as may be seen by referring to *Fig. 3.* The blue deep lake water comes close up to the shore, so that generally no breaker line is developed off shore. In several places there are numerous reefs or islands (usually the isolated continuations of the rock ridges), which tend to break the force of the waves rolling in from the open lake.

No effort was made to study the life of the open lake, only the shallow water of the bays and coves being examined. The major environmental features of the coast are the Lower, Middle and Upper Beaches; but these are only differentiated clearly at the heads of the coves and harbors. The Lower and Middle Beaches are only seasonal expressions of the same phenomena, but ecologically they are fairly distinct.

The Lower Beach. This beach extends from the shallow water to the upper limit of the summer waves. The submerged portion is not sharply defined above on account of the changes in level of the water surface, due to waves, the periodical and seasonal fluctuations, and the atmospheric pressure (seiches). In time there has been a downward migration of the entire beach zone, a tendency which is in part counteracted by the northward elevation of the land. This is the zone dominated by water, ice, and wave action. It is certainly a sharply defined tension line upon an exposed coast, which clearly suggests that it is not probable that many forms of animals have made the transition from fresh water to the land under such conditions. If we consider the shore habitats as including all stages from a rock cliff to the sand beach, the lower beach and the protected shores are the most favorable aquatic habitats upon such shores.

Upon the sloping rock, shingle, gravel and sand beaches is found a varied fauna. In winter, when the bays are frozen over, a calm is produced which must be favorable to the preservation of the aquatic life upon this stormy coast.

The general character of the sandy beach at the head of Conglomerate Bay is shown in *Fig. 4.* The life of the submerged portion of the shore is quite limited, except on the beaches and protected portions. The vege-

tation consists of algae, which grows in moderate abundance, though not luxuriantly, as found about the Gull Rookery (V, 10), or at the fishermen's camp at Rock Harbor, a fact which suggests that the abundance of suitable nitrogenous material is much greater in such places than in the open lake water. With the development of the fall storms, Mr. J. A. Malone states that these rocks (V. 10) are washed free of the algae, thus evidently necessitating a repopulation of these surfaces each season.

The characteristic fauna secured in the shallow water shore margins were the snails, *Limnaea stagnalis*, *L. emarginata*, and *Physa sayii*. A small fish, the Miller's Thumb, *Uranidea franklini*, is also fairly abundant and characteristic of this shore.

Upon low rocky shores beach pools, *Fig. 5*, are occasionally found which, when favorably located, are supplied with water by the ordinary summer waves, otherwise by storm waves and rains. The precarious existence of life in such places is indicated by the general type of the fauna, which shows exceptional power of locomotion, usually coupled with a short life cycle. The immature stages of insects are rather characteristic, as shown by nymphs of the water boatmen, *Corixa*, dragonflies and Caddis fly larvae. Water beetles were represented by *Rhantus binotatus*, and the snails by *Limnaea emarginata* and *Planorbis parvus*. The Gulls and Spotted Sandpipers should be mentioned as birds which frequent these conditions.

The Middle Beach. This beach occupies the strip of shore over which the winter waves retreat as they fall to the upper summer storm limit. It is thus seen that the Middle Beach is only a temporary or summer abandonment of part of the upper shore, which is repeatedly claimed by the winter waves. In summer this strip is exposed to denudation; in the fall and early winter, to the fury of the waves, and, later, it is covered with ice. Driftwood and debris tend to lodge here and to accumulate. It is an important region of biotic invasion for land forms. Beach pools are also developed in this area, upon the abandoned wave cut terraces of earlier lake levels. Upon the cliff faces, sloping rock shores and shingle beaches, little is found that is favorable to life, but upon the protected sand of the Middle Beach, relatively favorable conditions for many organisms are found during its period of exposure. The character of the substratum of the Middle Beach varies from rock to shingle, gravel and sand.

The characteristic features of the vegetation, where the wave action is not too severe, are the fruits which are washed ashore by the waves, together with certain annuals and lichens. The fauna varies with the character of the conditions. The open character of this beach and the relative abundance of animal food makes such situations favorable for spiders of the genus *Pardosa*. The same open character makes the shores a favorable patrol for certain butterflies, particularly *Basilarchia arthemis*. Insects and snails washed ashore by the waves also characterize this habitat.

The Upper Beach. This part of the beach is beyond the reach of the waves, and forms the transition between the open beach area and the inland forests. The width of this belt varies greatly with the gradient of the shore. Where the beach is continuous with a more or less bare rock

ridge, this habitat may be rather extensive and ill defined, as at the ridge south of the light-house (I, 2), but when it borders a depression, as at the head of the rockbound coves, or where a beach is well developed, this transitional zone is more clearly defined and limited. When this beach is wide and grades into the rock openings, as in *Figures 6 and 7*, the crustaceous and foliaceous lichens grow upon the rocks; but if soil accumulates, as is shown in *Fig. 6*, the *Cladonia*—Bearberry society becomes established, and includes some annuals, such as *Solidago*. A limited variety of insects, especially ants, characterize such conditions. When adjacent to the forests, in depressions, this beach is generally bordered by alders, some aspens and young trees.

The fauna consists largely of insects, such as butterflies, certain dragonflies and Hymenoptera, which frequent the open places on wing.

Station I, Substation 2. Natural Rock Clearings. This Station consists of two small rock openings, one just north of the light-house, and the other south of it, on the north side of the entrance to Tonkin Bay, only a short distance from the light-house. They were both park-like avenues extending along the ridges, largely bordered by the Balsam-Spruce forest.

The north ridge will first be considered. The general character of the opening is well shown in *Fig. 8*. The White Spruce, Balsam, Paper Birch and Arbor Vitae bound the ridge on either side, within which there is a distinct heath zone of Bearberry and patches of *Cladonia*, while along the central aisle there is a shallow residual and humic soil on the almost bare rock. The south slope is rather gradual, but the north slope and the end of the ridge at the shore form a cliff.

The fauna of this location was limited. Snails were found among the *Cladonia*, such as *Vertigo, Zonitoides arborea* and *Pyramidula cronkheitei anthonyi*. This was also a runway for Hares.

The south opening or clearing is situated on a low sandstone ridge which slopes down to the beach, and is thus in marked contrast to the north clearing, which ended in a cliff. This gradual slope beautifully illustrates the transition from the bare rock beach, through the moss and lichen zone, to the *Cladonia*, Bearberry and *Solidago* flora, (*Figs. 6 and 7*), and on to the crest of the ridge, *Fig. 9*, with its dominance of *Cladonia* and Bearberry. The severity of the conditions is furthered by the weathering of the sandstone into thin scale like layers, about ¼ of an inch thick, which become loosened and slide down the slope. Thus a vegetation may become fixed to the rock surface, but not permanently to the slope. These scale like fragments are shown in *Fig. 6*. That a greater amount of vegetation would grow here, if the soil were allowed to accumulate, is shown in Fig. 6, where such conditions have been produced by the presence of a larger boulder. The *Cladonia*-Bearberry avenue extends along the crest of the ridge, *Fig. 9*. This is bounded by large Jack Pines near the beach, and farther from the shore by the Balsam-Birch forest.

The zonal distribution on the ridges is quite marked; the central strip is composed of *Cladonia*, Bearberry, *Solidago*, and *Linnea borealis;* while this is bordered by a shrub zone composed of *Juniperus nana*, alder, Arbor Vitae and young Balsams, and a bordering tree zone is composed primarily of Balsam. When once the shade of the forest, es-

specially that of the Balsams, encroaches upon the *Cladonia* society, the Bearberry first becomes reduced in number, and is then replaced by *Aster macrophyllus*, and a moss from the forest floor. The former is perhaps the most striking and characteristic shade plant upon Isle Royale. The succession, or order of invasion on the ridge, from the *Cladonia* to the Juniper and into the Balsam forest, is thus briefly shown in the transverse section from the central ridge to its margin. This zonal phenomenon, as will be seen later, is only an expression of the relative rates of invasion, and is not a phenomenon separate from the normal succession.

The soil upon the top of the ridge is about two inches deep. It is residual, supplemented by the humus from a now extinct crustaceous lichen society (that of the *Cladonia*-Bearberry), and at its margins by the Juniper, Balsam, Birch and Jack Pine leaves and debris and further, to an important degree, by the excrement of the numerous Varying Hares which frequent the rock ridges.

In the case of rock ridges which entend down to the beach and are thus in direct communication with the shore drift, conditions exist which show how such ridges may have been invaded by lichens from two sources—the shore drift and the exposed beach itself—because of the continuity of the rock habitat. Of course possibly another origin is to be found in the fact that this ridge was itself once a beach. Ants, grasshoppers and a few other insects characterize this fauna, which is limited in variety, but fairly abundant in individuals. The Hares are abundant and form distinct paths or runways, as shown in *Fig. 9*.

Station I, Substation 3. Balsam-White Spruce Forest. This station included the forest traversed by a blazed trail from near the southeastern part of Sta. I, 2, and extended northward to the clearing about the light-house (I, 7), and beyond it to the north rock clearing (I, 2). Most of the region occupied by the forest is of low relief, with an occasional low rock ridge or hill. The dominant tree was the Balsam Fir, with much Paper Birch and White Spruce. Where the forest was very dense, especially if due to the number of Balsams, the ground was densely shaded and there was almost no herbaceous ground cover; but wherever there was a small opening, due to a fallen tree, or where one had been cut down, there was an abundant growth of Large-leaved Aster and White-flowering Raspberry; and it was in the midst of such conditions that young Balsams abounded. These were very characteristic plants in such conditions. In most cases a thick layer of humus covered the ground, but the tree growth was of small size. The common size of the Balsam was about 4 inches, the larger ones reaching 8 to 10 inches. The Birches averaged larger, usually about 6 inches. No evidence of burns were seen, but probably many trees have been cut from this vicinity, because of its proximity to the light-house, and the former Indian campground now occupied by the fishermen. The Balsam appeared to become dominant at this place, as more young trees of this species were seen than of any other.

The fauna found in this forest was rather limited, and doubtless great numbers of the insects which were taken in the clearing about the light-house (I, 7), bred in the adjacent forests. This is particularly true of the Cerambycids and other wood infesting beetles, the wood-boring

Hymenoptera (*Urocerus*), and their parasites. In addition to such species as feed upon Balsam, White Spruce and Paper Birch and their associated vegetation, there were those animals which are dependent upon the shade, moisture, soil, decaying logs and other features associated with forests. To this class belong certain insects which frequent decaying timber or the fungi growing upon them, and the earthworms of the soil, the ground beetles or Carabids, and the ground-inhabiting spiders, Lycosids. Some of the birds found were: Chickadee, Red-breasted Nuthatch, Golden-crowned Kinglet, Whitewinged Crossbill and Purple Finch.

Station I, 4. Tamarack and Arbor Vitae or White Spruce Swamps. This swamp is located in one of the valleys near the head of Tonkin Bay, and extends back from the bay about one-fourth of a mile. It begins just back of the beach and is bordered by a strip of Alders, Paper Birch, Mountain Ash, young Balsams and White Spruces. The rock walls of this valley are about 75 or 100 feet apart and are well shaded and covered by lichens and mosses, the south surface largely by lichens alone. Back of the marginal beach strip above mentioned, comes the dense growth of very large Arbor Vitae trees, intermingled with numerous large fallen trunks, partially decayed and covered with a dense growth of mosses. In the dryer places the ground is covered with a dense litter, and a thick damp or wet mass of mosses, but no pools of water. The undergrowth is composed of young Balsams, Birch and Ground Hemlock, *Fig. 10.*

Proceeding farther up the valley, the Arbor Vitae is replaced by Balsams and Paper Birch; the forest is more open, and the amount of moss on the ground is greatly reduced, and is replaced by a growth of Large-leaved Aster and large quantities of Ground Hemlock—all of this vegetation being indicative of mesophytic conditions. In this region there are scattered pockets or small pools of water containing dogwoods. Still farther up the valley the Balsams and Arbor Vitae continue and Tamaracks are added, but no standing water was found. The valley turns, and returns to the bay on the north side of the ridge which bounds the Arbor Vitae swamp on the north; the entire basin is thus somewhat horseshoe shaped. The returning section becomes almost pure Tamarack and contains numerous small pools of water. The conspicuous feature of this environment is its jungle-like character, the rapid accumulation of litter and humus, and the damp substratum.

The fauna of such a bog is surprisingly limited in variety and amount. A few shells were found, as *Pyramidula cronkheitei anthonyi* and, in the small pools, *Pisidium*. The large numbers of Mosquitoes and Black Flies made up for all deficiencies, and were almost intolerable. The birds frequenting this forest were the Red-breasted Nuthatch, Black-throated Green Warbler and Chickadee.

Station I, 5. The Jack Pine Ridge. This ridge is located near the mouth of Conglomerate Bay, on the north shore. Some general idea of the location is given in *Fig. 11*, which is a view looking toward the head of Conglomerate Bay. Just back of the beach, on an outcrop of conglomerate, was a small rock clearing, with *Cladonia*, *Juniperus nana*, and a wild rose. From here the trail extended through a narrow strip of forest, composed of Balsams, White Spruce and Arbor Vitae, with an

undergrowth of Balsam, Mountain Alder, and a ground cover of Large-leaved Aster, and passed on through a belt of young growth of Birch, with the usual White-flowering Raspberry and Large-leaved Aster, *Fig. 12*, and up the face of an escarpment to the crest of the ridge, which had a height of about 100 feet above the lake level. From the abundance and characteristic growth of Jack Pines on this ridge, the station takes its name. Part of the ridge has been burned over, as was shown by the burned and fallen timber, but the part to which our attention was given was apparently an original growth. The Jack Pine was scattered, and largely occupied the depressions and the larger crevices. The ridge is fairly flat topped, but is occasionally broken by transverse gullies, which contain Aspens, Birches, etc. The surface of the lava has weathered but little in some places, the original *roche moutonées* surface being very clearly preserved, and the planed glacial surface but little eroded. Near the escarpment, however, disintegration and decomposition have been much more active, probably influenced in part by lake waves at former levels, thereby developing a talus slope, composed of angular blocks, and in some places forming a stony soil. All intermediate stages are found between these two extremes. In addition to the large amount of bare rock surface, and that covered by only a thin layer of soil and vegetation, the shallowness of the soil is further evidenced by overturned trees, *Fig. 13*. This soil is of residual and organic origin, the crustaceous lichens and the Cladonia-Bearberry society, and later the Jack Pines, having contributed much to its formation. The excrement of the Hares has also been an important factor in soil formation, and that of the Lynx also, though to a much less degree.

The process of weathering must be relatively rapid on this ridge, because it is exposed to the winds at all seasons of the year, and to the marked seasonal and daily changes of temperature. The heat of the noonday sun is excessive, and the radiation from the nearly bare rock must be rapid, as it also is at night, so that the various influences consequent to temperature changes are allowed full play. Weathering is further favored by the irregularities of the surface, and the crevices, which allow the accumulation and downward conduction of this moisture, thus permitting the prying action of ice.

In general, the succession of plant societies on this ridge appears to be about as follows: Lichens are the pioneers on the rock surface, and these may be of several species, *Umbilicaria*, and the crustaceous and foliaceous forms. As a soil develops in the crevices or on the surfaces, these are followed by *Cladonia*, Bearberry, *Sibbaldiopsis tridentata, Solidago, Diervilla diervilla* (Bush Honeysuckle); and later, when the soil becomes deeper, by *Amelanchier, Prunus pennsylvanica* (probably dispersed to these ridges by birds) and *Juniperus nana*. The presence of the Small-toothed Aspen, willow and an occasional Birch probably indicates the next society. In the shade of the Birches and Jack Pines *Solidago* and *Aster macrophyllus* occur, if sufficient soil is developed. From the character of the vegetation in the ravines which traversed the ridge, and upon the talus slope toward the bay, it is apparent that the next society tends to be that of Birch and Aspen with some Balsam, Pennsylvania Cherry, Mt. Alder; and a ground cover of Large-leaved Aster, Large-flowering Raspberry, Ground Cornel and *Lycopodium*. It

is clearly seen that among these there are several elements of the Balsam, White Spruce and Birch forest society, which tends to ultimately possess the ridge.

The fauna of the ridge is quite diversified, and there is a general faunal correlation corresponding with these successions of the vegetation. Thus during the Lichen-Heath stage, ants and spiders, certain shells, and grasshoppers are abundant. As the soil becomes thicker or the crevices deepen, a subterranean fauna, consisting of myriapods, earthworms, etc., develops. As shrubs and trees encroach in patches, the animals frequenting the open tend to perpetuate themselves mainly at the open margins. From this condition on, so far as the fauna is concerned, it is largely a question of an "opening" or a forest environment. So long as this habitat remains open, the grasshoppers, ants, spiders, butterflies, flies, and certain Hymenoptera, Hares and Bats are characteristic, and this condition tends to continue as long as the trees are scattered. The *Cicada* is very characteristic of the Jack Pine stage, and although it occurs elsewhere in young Birches it is not so characteristic as on these hot ridges. With the advent of the Balsam-Birch society, which is slowly encroaching upon the ridges, the forms frequenting the open will disappear, or linger in the open spots where local conditions have retarded the advance of the forest. Only a few birds were seen here, but Hares had been numerous, as was shown by the large amount of excrement, and there was similar evidence of the occurrence of the Lynx. A bat was flushed from under a stone at the edge of the escarpment.

Station I, 6. Tamarack-Spruce Bog. This is a very small bog located at the base of the north slope of the Jack Pine Ridge (I, 5), and roughly estimated as about 250 by 300 feet in extent. The central part is covered with sphagnum, Cassandra, and a scattered growth of Labrador Tea. Widely scattered throughout the bog occur Tamaracks and Black Spruces, small Birches, Dwarf Cranberry, Cotton Grass and alders. No standing open water was found in this area, nor was the bottom quaking. Bordering the sphagnum zone is one of alders, willows, and a tall grass which merged into a zone of Tamaracks, willows, alders, Cassandra and Balsam, *Fig. 14*. Along the western end a narrow strip of water, a few inches deep, was found, which flowed through a ravine across the ridge. Along this outlet the deeper soil and moisture has permitted the development of Balsam, Birch, Small-toothed Aspen, Mt. Maple, Ground Hemlock, Ground Cornel, Large-leaved Aster, and a few Black Ash trees.

The fauna, like the vegetation, was not studied in detail, but the following general relations were observed. In the open central Sphagnum-Cassandra society were numerous large ant nests. A Toad was observed here; and the following birds: Golden-crowned Kinglet, White-throated Sparrow, Cedar Waxwing, and Black-throated Green Warbler.

Station I, 7. Light-house Clearing. This was a small clearing which has been made about the Light-house: it connects by a path to the fishing camp on Rock Harbor. It covers about half an acre, and was originally, in all probability, a Balsam and Spruce forest like the surrounding forest. A sod covered much of the ground, and there were numerous

weeds, of which the Cow Parsnip umbels furnished excellent places for collecting Syrphid flies, Cerambycid beetles and Hymenoptera.

The fauna of this clearing consisted largely of insects which frequent flowers, and butterflies which fly in open places; but a few animals were found about the Light-house itself. The Chipping Sparrow bred in this clearing. *Fig. 1.*

Station II. This station included the clearing at the mouth of the stream which drained Lake Benson, and which we called Benson Brook, and followed the blazed trail to Sargent Lake, and on to McCargoe Cove. The clearing at the beginning of the trail at Rock Harbor marks the site of the former settlement called Ransom on the old maps.

Station II, Substation 1. Ransom Clearing and Benson Brook. The clearing was occupied by scattered Small-toothed Aspens and Birches, and was well sodded with grass and Red Clover. Our attention was called to this locality because of the great number of Garter Snakes (*Thamnophis sirtalis*) which were found there. These snakes were very abundant in a small area east of the mouth of the brook, in a rank growth of grass and among some rails.

The brook contained but little life, although it was carefully examined near its mouth and farther back where the trail crosses the brook. Only a few dead *Physa* were found, and a young fish, at the mouth of the brook.

Station II, Substation 2. Tamarack Swamp. This is a long swamp which is crossed by the trail, and which contains a scattered tree growth of Tamaracks, Black Spruces and Arbor Vitae, a dense shrub growth of Cassandra and Labrador Tea, and a ground cover of Sphagnum and Pitcher Plants. While no water was seen on the surface, it was a wet swamp.

This locality was only examined for birds and mammals.

Station II, Substation 3. Rock Ridges. This station number is given to the open rock ridges which were crossed by the trail between II, 2 and Sargent Lake. These ridges have been burned over and are largely destitute of soil and the *Cladonia* growth usually found on other rock ridges. Small-toothed Aspens generally border these ridges which have a northeasterly southwesterly direction. The heat during the middle of the day is excessive. The scant vegetation which grows in some crevices and depressions in the rock leaves an open area which is decidedly favorable for grasshoppers. In some places they were exceedingly abundant and many ridges were examined almost solely for their grasshopper fauna. In the dry soil on one ridge an anti-lion larva was found in the dust at the base of its funnel, and a large Garter Snake was taken on another. The grasshoppers found here were *Chloealtis conspersa* and *abdominalis*, *Circotettix verruculatus*, *Melanoplus alaskanus* and *fasciatus*.

Station II, Substation 4. McCargoe Cove. This station simply marks the location of the end of the trail, and the cove where a few molluscs were found. There were dead shells of *Anodonta grandis footiana*, which were abundant at the edge of the water. Here upon the low rocky shore were also found specimens of *Limnaea stagnalis*.

Station II, Substation 5. Forbes Lake. The examination of this small lake was mainly confined to the north shore, as the south shore

FIG. 1. THE LIGHT-HOUSE AT ROCK HARBOR, ISLE ROYALE.

FIG. 2. CLIFFS BETWEEN TONKIN AND CONGLOMERATE BAYS.

FIG. 3. SUMMER STORM WAVES UPON THE BEACH (I, 1) AT THE HEAD OF TONKIN BAY, SOUTH OF THE LIGHT-HOUSE.

FIG. 4. SAND BEACH AT THE HEAD OF CONGLOMERATE BAY (I, 1).

FIG. 5. BEACH POOL (I, 1) NEAR TONKIN BAY.

FIG. 6. TRANSITION FROM THE BEACH (I, 1) TO ROCK CLEARING (I, 2), SOUTH OF THE LIGHT-HOUSE.

FIG. 7. NATURAL ROCK OPENING (I, 2) OR AVENUE, FARTHER UP THE SLOPE THAN IN FIG. 6.

FIG. 8. NATURAL ROCK CLEARING OR OPENING (I, 2) NORTH OF THE LIGHT-HOUSE AT ROCK HARBOR.

FIG. 9. NATURAL ROCK CLEARING (I, 2) SOUTH OF THE LIGHT-HOUSE, ADJACENT TO FIG. 7.

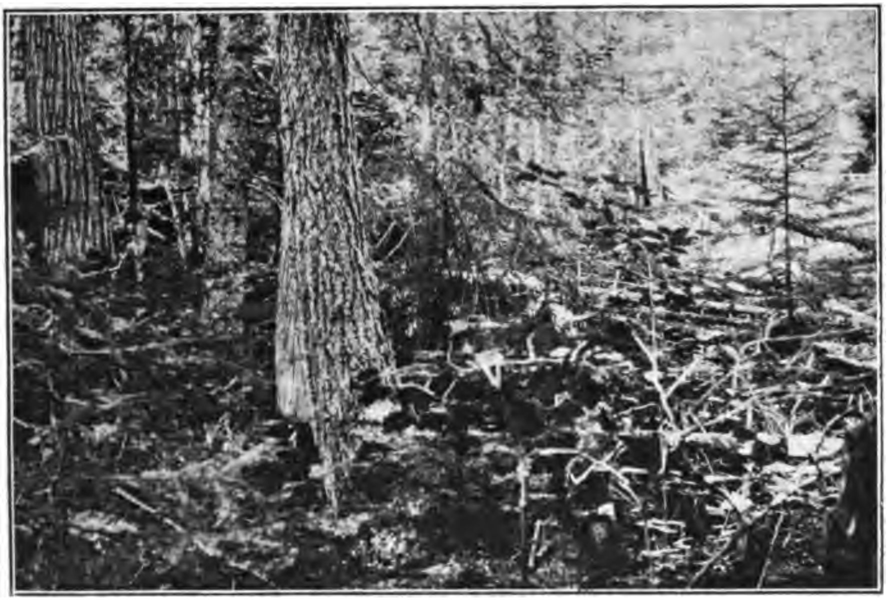

FIG. 10. ARBOR VITAE BOG (I, 4) NEAR TONKIN BAY.

FIG. 11. VIEW FROM THE JACK PINE RIDGE (I. 5). LOOKING TOWARD THE HEAD OF CONGLOMERATE BAY.

FIG. 12. SECOND GROWTH OF WHITE BIRCH ON THE TRAIL TO THE JACK PINE RIDGE (I, 5) CONGLOMERATE BAY.

FIG. 13. JACK PINE RIDGE (I, 5) CONGLOMERATE BAY.

FIG. 14. SPHAGNUM-BLACK SPRUCE BOG (I, 6) NEAR THE JACK PINE RIDGE.

FIG. 15. SMALL ISLANDS NEAR THE HEAD OF ROCK HARBOR (III, 1).

FIG. 16. BULRUSH ZONE AND DELTA AT THE HEAD OF ROCK HARBOR (III, 3).

FIG. 17. EXPOSED SECTION OF SPIT FORMED AS THE WATER LEVEL HAS LOWERED IN ROCK HARBOR, NEAR THE BEGINNING OF THE TRAIL TO SUMNER LAKE (III, 4).

FIG. 18. SUMNER LAKE (III. 5), EASTERN END.

FIG. 19. WESTERN END OF SUMNER LAKE (III. 5).

FIG. 20. NORTHEASTERN MARGIN OF SUMNER LAKE (III, 5).

FIG. 21. SOUTHEASTERN CORNER OF SUMNER LAKE (III, 5).

FIG. 22. WESTERN END OF SUMNER LAKE (III, 5).

FIG. 23. NORTHERN SHORE OF SUMNER LAKE (III, 5).

FIG. 24. ROCK OPENING ABOUT CAMP ON SISKOWIT BAY (V, 3).

FIG. 25. ROCK OPENING AT SISKOWIT CAMP (V, 3).

FIG. 26. ROCK OPENING ON SISKOWIT BAY (V, 3).

FIG. 27. BORDER OF THE OPENING ABOUT THE SISKOWIT CAMP (V, 3), NEAR THE BEGINNING OF THE TRAIL TO SISKOWIT LAKE (V, 4).

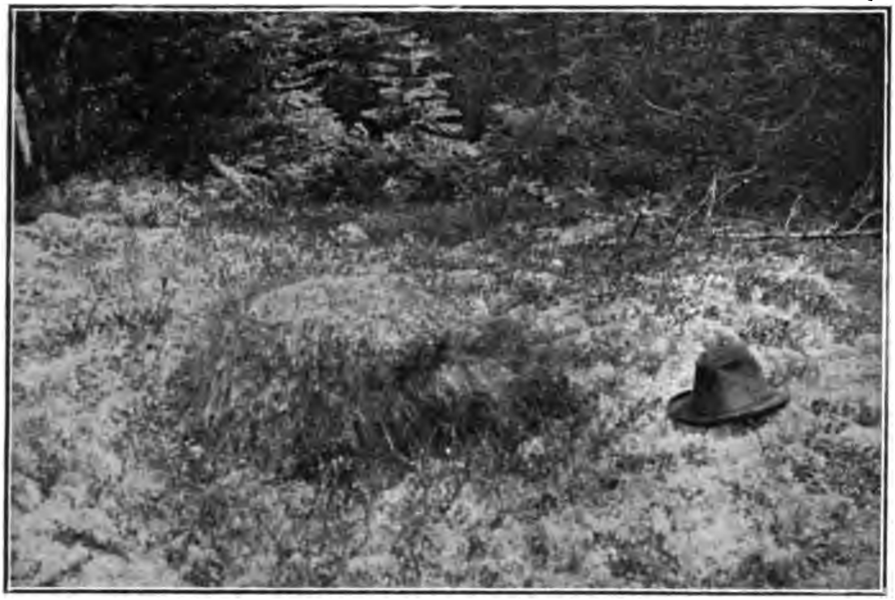

FIG. 28. ANT NEST IN THE OPENING AT THE SISKOWIT CAMP (V, 3).

FIG. 29. GENERAL CHARACTER OF THE SOUTH SHORE, NEAR THE EASTERN ENTRANCE TO SISKOWIT BAY (V, 2).

FIG. 30. ROCK POOL ON THE BEACH (V, 2), WHERE A VARIETY OF INVERTEBRATES WAS SECURED.

FIG. 31. SAXIFRAGA AIZOON ON BEACH (V, 2).

FIG. 32. GENERAL VIEW ALONG THE SHORE AT V, 2.

FIG. 33. FARTHER UP THE SAME SLOPE AS IN FIG. 32 AND ADJACENT TO IT.

FIG. 34. STILL FARTHER UP THE SLOPE AND ADJACENT TO FIG. 33.

FIG. 35. LOOKING UP THE SLOPE ON THE WESTERN PORTION OF STATION V, 2.

FIG. 36. UPPER PORTION OF WESTERN PART OF STATION V, 2.

FIG. 37. DETAIL OF WESTERN PART OF STATION V, 2.

FIG. 38. CHARACTER OF GROUND COVER IN PARTS OF THE BALSAM-SPRUCE FOREST (V, 4).

FIG. 39. OPEN SPACE IN THE BALSAM-BIRCH FOREST (V, 4).

FIG. 40. OPEN SPACE IN THE BALSAM-BIRCH FOREST (V, 4).

FIG. 41. TAMARACK SWAMP (V, 5).

FIG. 42. SPRUCE MARGIN OF STATION V, 5.

FIG. 43. BLACK SPRUCE MARGIN OF STATION V, 5.

FIG. 44. BOG MARGIN OF STATION V, 5.

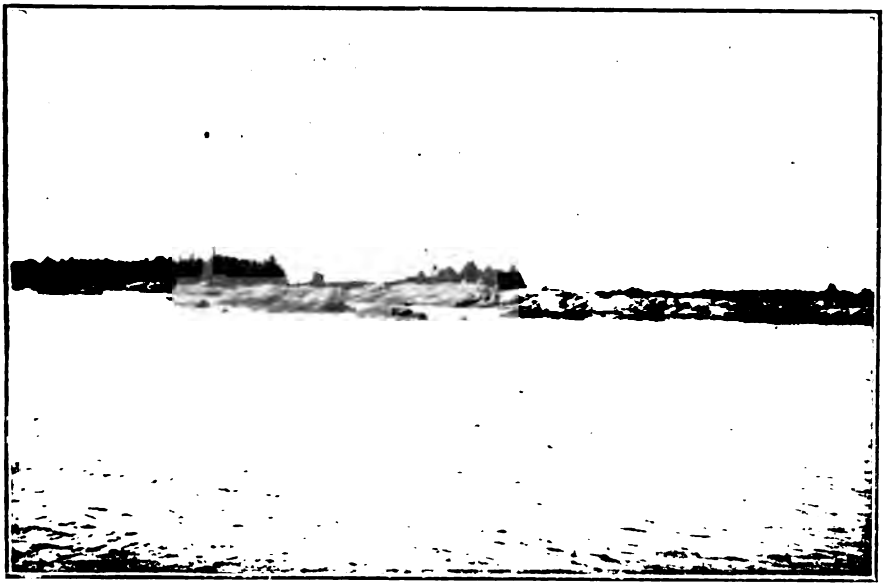

FIG. 45. LONG ISLAND GULL ROOKERY, (V, 10).

FIG. 46. POND IN TAMARACK—BLACK SPRUCE SWAMP (V, 11).

FIG. 47. MARGIN OF LILY POND (V, 11).

FIG. 48. BLACK SPRUCE IN CASSANDRA ZONE OF STATION (V, 11).

FIG. 49. MAPLE FOREST ON THE DESOR TRAIL (III, '04).

FIG. 50. FOREST ALONG WASHINGTON BROOK (IV, '04).

is rocky and steep, with Birches and other trees growing down to the water. The north shore has been largely burned over, and is being replaced by Birches and Small-toothed Aspens, which are now dominant; the undergrowth consists of alders and the abundant Large-leaved Aster. The water in the lake is brownish. At the western end there are White Waterlilies, near the shore Yellow Waterlilies, *Caltha palustris*, *Equisetum*, and farther back Cassandra and alders, Tamarack, Arbor Vitae, and Black Spruce.

On the north shore a rocky point projects into the water, and east of this along the shore is a floating sphagnum bog, ranging in width from about 40 to 100 feet and containing Pitcher Plants, Low Cranberry, Buckbean, scattered sedges and Blue Flags, and a shrub growth of Cassandra, Labrador Tea and Wild Rosemary. Scattered trees of Tamaracks, Arbor Vitae, and Black Spruce grow to the edge of the water. Water stands in the small depressions over this bog.

The fauna was not studied in detail, but the forms collected were as follows: The spider, *Pardosa glacialis*, with egg masses, was found running about over the wet sphagnum; a dragonfly, *Aeschna*, was seen on wing; two species of grasshoppers were found in the wet Sphagnum; *Melanoplus extremus* and, in the wetter places, nymphs of *Mecostethus lineatus* were quite abundant. There were also great numbers of mosquitoes and Black Flies. Upon some driftwood near the end of the lake was found *Physa gyrina* (No. 71 A.). Yellow Perch were so abundant in this lake that locally it is called Perch Lake. A Canada Jay was seen in the top of a tree.

Station III. Western End of Rock Harbor. This station was intended to include those localities near the western end of Rock Harbor.

Station III, Substation 1 and 2. Small Island. The general character of this island is shown in *Fig. 15*. This is a small, rocky, wooded island, the trees consisting of one large White Pine, about 14 inches in diameter, Arbor Vitae, Birch, Balsam, and White Spruce, the dominant ones being the Balsam, Arbor Vitae and Birch, with a shrub growth of Mt. Alder, Willow, Nine-bark, Mountain Ash, *Amelanchier alnifolia*. Upon the rock occurred *Cladonia*, Bearberry, and Low Juniper, and toward the western end of the island, where the trees shade the ground, grew *Lycopodium complanatum*, mosses and *Clintonia borealis*.

Of the fauna, the bird life only was examined; Cedar Birds and a Song sparrow nested here, the former being quite abundant.

The submerged western end of this island formed Station III, 2. The bottom was composed of sand and angular rocks. In the shallower water *Anodonta grandis footiana* valves were found, and live animals in water about 18 inches deep. These rocks also furnished a number of *Limnaea stagnalis*, and a dead specimen of *Planorbis bicarinatus*. A few scattered rushes (*Scirpus*) grew at this place.

Station III. Substation 3 and 6. Head of Rock Harbor. These stations include the delta at the mouth of the largest stream flowing into the Harbor, Station 3, and the sandy and rocky shallow water zone extending from III, 2 around the head of the Harbor, Station 6.

The general character of the delta, III, 3, region is shown in *Fig. 16*. This small delta had been formed by a small sluggish brown-stained brook, 15 or 20 feet wide, which enters the Harbor at this point. The

channel contained a growth of *Vallisneria spiralis, Potamogeton crispis*, and the banks supported a growth of sedges, *Lycopodium complanatum, Clintonia borealis*, alders and Mountain Ash. The surface of the delta is strewn with driftwood and other plant remains, upon a clean sandy bottom. Nearer the shore, upon a muddy bottom, were found an abundance of Amphipod crustaceans, *Hyalella knickerbockeri, Gammerus limnaeus*, and the small bivalve molluscs, *Pisidium*. The fresh water sponge, *Spongilla lacustris*, was found here, and water striders, *Gerris remigis*, were found on the surface. Individuals were abundant, so that the fauna is relatively varied.

Substation 6 included the southwestern coves of the Harbor. The bottom was rocky, and covered in places with much sand; the water was shallow and contained, near the shore, many patches of rushes, *Scirpus* and *Equisetum*. *Anodonta grandis footiana, Limnaea stagnalis* and *Pisidium* were the characteristic molluscs, and a few fish were found.

The protected character of the shore is noteworthy, as no beach is developed, because the coves are protected from the heavy lake waves. Another characteristic feature is the sand bottom. This sand is carried toward the head of the Harbor by the currents. Even at higher Lake levels, this Harbor was sandy, as is shown by the sand banks on the north shore, and these are being re-worked by currents and waves and carried up the Harbor. The spit developing from the south shore, *Fig. 17*, illustrates this.

Station III, Substations 4 and 5. Sumner Lake and Trail. The trail to Sumner Lake (III, 4), begins on the south shore of Rock Harbor and extends south about one-half mile to Sumner Lake. It passes through a second growth of Birch and Aspen (which has followed a burn), a small Arbor Vitae swamp, over a rock ridge to the north shore of the lake, where there are a few large Norway Pines, from 12 to 15 inches in diameter, and a few White Pines. But little attention was given to the life along the trail, although a few observations on the bird life were made, and some mammals were trapped. However, Sumner Lake proved to be such an interesting locality that attention was given to it more especially than to the trail. This lake has many of the characteristics of a large lily pond, because the White Waterlilies and Potamogetons form such a wide belt around the lake. *Figs. 18-23*. In passing from the interior of the lake toward the shore, the following zones of vegetation are found: The bulrush zone, which is well developed, with its denser growth about the eastern end; then the Yellow Waterlilies, followed by the dense sedge zone which produces a substratum. In the eastern and western ends of the lake the water gradually shallows; but on the sides the change is more abrupt, thus interrupting the shallow water zone of sedges, as shown on the north shore, *Fig. 23*. This encroachment of vegetation upon each end of the lake is very marked, and is much more extensive at the eastern end, where the lake is drained into the head of Conglomerate Bay by a small brook. The encroachment at the western end of the lake is well shown in *Fig. 19*. A partial view of the eastern end of the lake is given in *Fig. 18*. The sedge zone contains a variety of plants, including several orchids, Iris, Pitcher Plants, Buckbean, scattered Eriophorum and Sphagnum, Cassandra and Andromeda. The substratum is quaking and sinks

several inches below the water level with the weight of one's body; occasionally small but deep holes are found through this substratum, and care must be taken to avoid them. This zone is very broad and contains an abundance of life. Outside the sedge zone occur alders and Tamaracks, which border the forests at the base of the slopes.

The fauna of the open Waterlily, Bulrush and Potamogeton zone consists of insects flying over the water, such as the dragonfly, *Aeschna* and the leaf beetles *Donacia,* which abound, especially about the Yellow Waterlilies. On the surface film were water striders, *Gerris marginatus,* and whirligig beetles, Gyrinidae. Sticklebacks were abundant, and are quite characteristic of such waters, as is another small fish. Loons were frequently seen here, and also a Hooded Merganser. Toward the outer margin of this zone where the lilies are often closely matted on the surface, the insect life and the surface film fauna are the most abundant. A live mussel, *Anodonta grandis footiana,* was found on the bottom; and the snails, *Planorbis campanulatus* and *parvus,* were found in small pools in this sedge zone. The bottom in this vicinity, and that bordering the water margin of the ridges, is covered with a mass of partly floating debris, the appearance of which suggested to Wood, who first observed it, that something had exploded and scattered the strands of debris about the surface. It is not improbable that the formation of marsh gases will adequately explain this phenomenon, (Cf. Penhallow, Science Vol. 22, 1905, pp. 794-796).

The dragonflies were *Enallagma hageni, Aeschna, Somatochlora shurtleffi,* and *Lucorhina proxima*, the last being very abundant.

Where the sedge zone was absent, as at our raft landing at the end of the trail, an abundance of needles, leaves and twigs from the overhanging conifers and hardwoood had accumulated at the shore, and were stained almost black. The water of the lake is brownish. At this point a number of invertebrates were taken, including shells, leeches, insects, etc.

Station IV. Tobin Harbor and Vicinity. As very little time was spent at this station, the description will be correspondingly brief. Tobin Harbor is a deep, narrow, protected bay, similar to that at the head of Rock Harbor, but narrower. The adjacent hills are forest covered, largely with Aspen and White Birch. In the vicinity of Neutson's Resort there is a large, cleared area. Mattson's resort is located on an island in this Harbor. The most marked scenic feature of the Island, Monument Rock, is on the north side of Tobin Harbor.

It is a noticeable fact that many of the low islands in Tobin Harbor, and especially those near its eastern end, are clothed with vegetation close to the edge of the water. They are thus in marked contrast with the islands along the southern shore, and to the various points of rocks which project into the water.

Upon a small island, Number 14 on the Land Office map, were found small rock beach pools, just above or near the height of the usual quiet weather waves. The water in one was about a foot in depth and contained a very small amount of algal growth. In this pool were found water striders, *Gerris remigis,* a few other insects (No. 30), and small tadpoles. In another small pool about 10 inches above lake level, and with a temperature of 77° (the Harbor water having a temperature at the

time of 50° F.), were many species of *Limnaea catascopium* and a few adult *Physa*. Algae were only seen in the crevices.

Station IV, Substations 1 and 2. Rock Pools and Scovill Point. Scovill Point is an almost bare, glacially planed, narrow and low rock ridge, projecting out into the lake. Numerous small faults occur on the sloping southern side, and these, supplemented by the waves, etc., have produced rock pools. In one case a long row of pools occurred along the line of the fault. The presence of tadpoles about an inch long would suggest that these pools have some duration. The higher summer waves might also reach many of these pools. Water striders, *Gerris*, are abundant upon the surface, and a large deep ravine, near the lake level, contained Sticklebacks, but no shells were observed in any of these pools.

Station IV, Substation 3. Bayou East of the Monument Rock Trail. This is a very small pond which is connected with the Harbor by a small stream just large enough to admit a row boat. It illustrates the last stage of separation of the valleys from the Harbor, as only a very slight fall of the lake level would completely isolate it. In this particular case the outlet is on the south side, and not at one end as is usually the case. The central part of the pond is open water and is surrounded by an almost complete zone of Yellow Waterlilies, and a sedge zone containing several low shrubs. The Waterlilies were badly infested by a small leaf beetle, *Galerucella nymphaea;* larvae, pupae, and freshly emerged beetles were taken. A few dead shells of *Anodonta marginata* and one of *Limnaea megasoma* (the only specimen taken upon the island) were secured here. An extensive suspended flocculent mud covered the bottom, so that molluscs could not obtain a foothold. At the western end of this pond innumerable small tadpoles formed an almost compact pavement upon the bottom at the edge of the water. A few dragonflies were seen, but were not captured.

Station IV, Substation 4, 8 and 9. Forest on the Greenstone Range. These three stations are combined because they are related to the forest occupying the Greenstone range. The trail to Monument Rock (IV, 4) begins on the north shore of Tobin Harbor and extends northwest about one-half mile to Monument Rock. The forest is dense and is apparently a second growth of Balsam, White Spruce, Birch and Aspen, with underbrush of Mountain Alder, Mountain Ash, Ground Hemlock, and a ground cover of Few-flowered Cranberry, *Clintonia borealis, Linnea borealis,* and Wild Sarsaparilla. In the moist places was found Ground Cornel, *Aster macrophyllus*, an *Equisetum*, *Lycopodium*, and, in wet places of the swamp traversed, the Buckbean and Skunk Cabbage. For some distance on the slope down from the base of Monument Rock occur large blocks which are covered by a dense mat of mosses, and the ground is covered with a thick layer of humus, so that the general appearance of the vegetation is that of a mesophytic forest.

The trail up the Greenstone (IV, 8), begins at the mouth of a small brook at the head of Tobin Harbor, and follows the crest of an open burned over ridge southeast for about half a mile. This ridge contains a scanty growth of *Amelanchier oligocarpa* and *alnifolia*, *Prunus pennsylvanica,* Jack Pine, wild rose, *Solidago*, Bearberry and Yarrow. From the end of this ridge a valley crosses to the north and contains large

Aspens, Tamarack, Norway and White Pine, and an underbrush of Speckled Alder and Ground Hemlock. After crossing this depression, the trail ascends the slope and crosses the burned ridges where there is a growth of Birch and Aspen. The slope increases more abruptly as the crest of the Greenstone is approached. This is the vicinity of an old signal station and has an elevation of about 460 feet, according to the Lake Survey. This forest along the crest comprised Station IV, 9. The large trees stand above the surrounding second growth, on the burned area, and can be seen for some distance. The Balsam, Birch and Quaking Aspen are the dominant trees, the Balsams reaching a diameter of about 10 to 12 inches, and the Birches and Aspens about 12 to 15 inches. The shrub growth is composed of Mountain Maple, Ground Hemlock, and the Few flowered Cranberry, the ground cover of *Diervilla diervilla*, Large-flowering Raspberry, *Aster macrophyllus, Clintonia borealis, Linnea borealis, Lycopodium*, Wild Sarsaparilla and Brake Fern; the White and Black Spruces being only occasionally seen. This forest produced dense shade. Fallen timber is abundant in places, but no signs of fire were observed. This ridge was bounded on the north by a cliff of perhaps 20 to 30 feet, below which was a long talus slope covered with Birch, Aspen and Balsam. From the top of this ridge there is a splendid view to the north. The crest was followed west to a small open burned area where *Diervilla diervilla* and Large-flowering Raspberry were abundant. The leaves of the latter were badly perforated by the abundant grasshoppers, *Hibbiscus tuberculatus* and *Melanoplus alaskanus*. In the deep wood a Tree Toad, *Hyla versicolor*, was found, and Varying Hares and Red Squirrels were seen.

Station IV, Substation 5. Clearing, and Vicinity of Neutson's Resort (Park Place). There is a rather extensive clearing at Neutson's Resort, so that very little collecting was done in this vicinity. A collection of grasshoppers was made here by Brown and Wood, and the following list of plants was made by the former from the same vicinity: White Spruce, Birch, Aspen, Mountain Alder, *Juniperus nana*, Wild Red or Pennsylvania Cherry, Red and White Clover, Bush Honeysuckle, *Fragaria vesca*, Cow Parsnip, and *Lycopodium complanatum*.

The grasshoppers were: *Chloealtis abdominalis, Camnula pellucida, Hippiscus tuberculatus, Circotettix verruculatus, Melanoplus alaskanus*, and *huroni*. Two butterflies, *Argynnis atlantis* and *Pyrameis cardui*, and the dragonfly *Lestes unguiculatus* were also taken here. In Rock Harbor, at Neutson's, leech egg capsules of *Nephalopsis obscura*, and *Physa* were taken. On a small island across the Harbor to the south, in a Sphagnum, Pitcher Plant and Tamarack swamp, a number of Wood Frogs, (*Rana cantabrigensis*) were taken.

A Red-bellied Snake (*Storeria occipitomaculata*) was reported to have been killed in the clearing, during July.

Station IV, Substation 6. Small Island in Tobin Harbor. This station includes the sedges and shallow water at the west end of a small island in Tobin Harbor. The bottom was covered with sand and large angular blocks of rock. *Limnaea stagnalis* was very abundant and occurred in water with a depth of about three feet. The shells are very fragile. Upon the rocks *Physa* occurred in limited numbers and was widely scattered, but they were abundant on the stems of the sedges not far

below the surface. The young of *L. stagnalis* occurred with the *Physa.* A specimen of *Gordius aquaticus* was secured here.

Station IV, Substation 7. Head of Tobin Harbor. A small brook empties into the head of the Harbor, and its brown water brings into the bay quantities of vegetable remains and flocculent debris. These cover the bottom near the mouth of the stream, and although carefully examined, were found to be singularly free of animals. Upon patches of *Potamogeton perfoliatum* occurred a few *Physa,* and in the shallow water a few fish were found. (No. 35.)

Station V. Siskowit Bay, Lake, and Vicinity. This station includes all the localities in the vicinity of Siskowit Bay and Siskowit Lake, except that of VIII, '04, which is at the head of Siskowit Bay.

Station V, Substation 1 and 3. The Bay Beach at Camp, and the Rock Clearing. The beach (V, 1), is protected from the waves of the open lake and bay by large off-shore islands. The rock composing it is vesicular lava, and slopes to the water at an angle of about 10 degrees.

The Rock Clearing about Camp (V, 3), begins at the beach and extends up the slope backward to the Balsam, Spruce and Birch forest as a park-like opening. The soil, mainly of residual and humic origin, is very shallow and completely lacking in places. The surface of the rock is rough, showing that it has been eroded since glaciation. In places the rocks are more or less covered by crustaceous and foliaceous lichens, or, where there is more humus or soil, by *Cladonia, Fig. 24.* Where the soil is deeper is found Bearberry, Narrow-leaved Cow-wheat, *Solidago,* grasses and moss. A scattered shrub growth is composed of *Juniperus nana* and *Amelanchier, Fig. 25 and 26,* and the bordering tree growth consists of Balsam, Black and White Spruce, Birch and Arbor Vitae. In the shade of these bordering trees, *Aster macrophyllus* develops in abundance. The above description also outlines the probable succession of plant societies upon this surface, all stages of which are now to be found within this area. Many smaller patches of this open condition are found scattered through the forest and are becoming shaded and converted into the forest as a soil develops, *Fig. 27.*

The fauna of the openings is rather characteristic and abundant. Of course many species range over a variety of plant societies and only recognize a clearing or forest society, and not their varieties. Yet others are much more sensitive to smaller environmental units. This is well shown by certain ants. Ant nests of *Formica fusca* as illustrated by *Fig. 28,* and certain spiders, as *Pardosa,* are quite characteristic of the *Cladonia-Bearberry* plant society. The opening, as contrasted with the forest, is frequented by grasshoppers, such as *Melanoplus fasciatus;* butterflies, as *Argynnis* and *Basilarchia arthemis;* and the dragonflies, *Sympetrum,* which were very abundant and characteristic (*Aechna* patrols the margins of such openings). The robber fly, *Asilus annulatus,* frequents such open sunny areas where animal food abounds.

The vertebrate frequenters of the open were the Flickers, which were observed by McCreary to destroy ant nests. Several of such demolished nests were seen. Toward night a nocturnal association frequented the open; the bats on wing; and the hares came from the forest to feed, having been in hiding during the day.

No doubt the presence of this opening, in part, determined the location

of the log cabin used by our party. The logs were thoroughly infested by beetle larvae, and attracted vast numbers of parasitic Hymenoptera. For this reason, insect collecting about the cabin was of an exceptional character, and included a considerable variety of species. From the adjacent forest a number of trees had been cut, but this did not materially influence this locality, except near the shore.

Station V, Substation 2. Heath Zone and Beach. This locality includes a strip of rocky coast on the south shore of the island, a short distance east of the entrance of Siskowit Bay, *Fig. 29,* and extends from the edge of the water back to the forest. This is an exposed section of the coast and is unprotected by offshore islands, so that easterly storms from the open lake have full sweep on this shore. The slope is a fairly uniform rock surface, with an upward slant of about 10 degrees, and is composed of amygdaloidal lava. Crevices of various dimensions, from a mere crack to a deep rock ravine, extend obliquely up the slope. One of these ravines, the only large one, divides this station into two sections east and west. The eastern section of the slope is covered by a *Cladonia-Juniperus procumbens* society, while the western section is occupied by a *Cladonia-Juniperus nana*-Huckleberry society. Thus there are three fairly well defined natural divisions of this part of the coast, the beach, the *procumbens*, and the *nana* societies.

1. *The Beach.* The low angle of the slope, and the exposed situation and deep offshore water all combine to make the beach zones quite wide (four or five paces) upon this slope. No collections were made upon the submerged beach and only a few specimens were taken upon the lower. The characteristic species, however, were a small hemipterous shore insect, *Salda ligata,* a caddis fly, and ants. Above the lower beach is a wide upper one, characterized by a dark green moss (*Grimmia*) and crustaceous lichens.

A number of rock pools occupy the oblique crevices which extend up the beach. The largest of these is shown in *Fig. 30.* This is a pool about 4 x 8 feet in diameter and contains about 15 to 18 inches of water. On the surface of the water were fragments of insects, water striders, *Gerris remigis,* and on the bottom, dragonfly nymphs (No. 14), while caddis fly larvae crawled upon the sides and bottom. No algal growth was visible. The character of this insect life suggests a pool of some duration, but the absence of shells suggests a lack of permanent water. Numerous basin-like depressions, a few inches in depth, occur on the lower beach and on the foliaceous lichen-covered portions of the middle beach. The sharp angles of some of the pools show that these are occasionally produced by the removal of small blocks of rock. Most of the pools, however, occur in crevices. From one of the large pools a frog, *Rana clamitans* (No. 120), was taken, clearly showing how tadpoles may reach such pools.

In the crevices and behind angular rock projections occur Hare-bells, Yarrow, Ninebark, and an interesting succulent Saxifrage, *Saxifraga aizoon, Fig. 31,* and some grasses. In the crustaceous lichen zone is a greenish moss, *Grimmia,* and in the crevices are Bearberry, *Juniperus procumbens,* and Arbor Vitae.

2. *The Cladonia-Juniperus procumbens Society of the Eastern Section.* About ten paces farther up the slope, *Fig. 32,* this crevice society spreads

out, and, with the addition of *Cladonia* and some *Juniperus nana*, forms interrupted patches or streaks, *Fig. 33,* which farther up the slope fuse and form a solid mat, completely covering the surface of the rock, *Figs. 33 and 34.* The dominant forms are *Juniperus procumbens* and certain species of *Cladonia.* This was the only place where *J. procumbens* was found growing on such an extensive scale, or associated in abundance with *Cladonia.* This formed a novel and beautiful sight, the light-colored patches of the Reindeer-lichens in places intermingled with the bright green of the *procumbens* to form a variegated mat. The beauty of color and pattern is lost in a general view, as in *Fig. 34.* The White Spruce invades the slope in crevices, just in advance of the solid mat formation, but the soil is so shallow that it may be blown over, as is shown in *Fig. 33. Procumbens* grows so densely and close to the ground that it greatly favors the formation and retention of the soil, and it apparently precedes, on this slope, the *Cladonia.* In the large crevices within this zone grow patches of White Pine, Balsam, Mountain Alder, Spruce, Birch and Arbor Vitæ. The general relations of this slope can easily be seen by a comparison of *Figs. 32, 33 and 34.* in which is shown the transition from the bare wave washed beach, the flat growing lichens, the pioneers of the mat formation invading the crevices, and the dominance of the *J. procumbens-Cladonia* society with its scattered trees, up the slope into the Balsam-Spruce forest. This same order probably also expresses the succession of plant societies at this place. As previously mentioned, the fauna of the lower beach is quite limited, the greater variety occurring in the pools; but farther up the slope appear various forms which frequent the open. On the scattered part of the *Cladonia-procumbens* zone occurred the spiders, *Pardosa glacialis* and *sternalis*, the grasshoppers, *Circotettix verruculatus, Melanoplus alaskanus* and *fasciatus.* A ground beetle, *Pterostichus femoralis* was found under *Cladonia,* and under similar conditions were found an abundance of shells, *Acanthinula harpa, Strobilops virgo, Vertigo tridentata, Vitrina limpida, binneyana, Euconulus fulvus, Euconulus chersinus polygyratus, Zonitoides arborea milium, Agriolimax campestris, Pyramidula cronkheitei anthonyi, Helicodicus parallelus,* and *Cochlicopa lubrica.* The number of these shells which have a distinctly boreal range is particularly noteworthy, suggesting that such a habitat has some of the characteristics of a "boreal island."

3. *The Cladonia-Juniperus nana Society of the Western Section.* Here, as at the eastern section of this slope, the bare lake beach bounds this area shoreward. A general view up this slope is shown in *Fig. 35.* The bare wave-washed lower beach is in the foreground, and the green moss and light colored lichen zone is a broad belt above it, followed in turn by foliaceous lichens, and in the crevices by Aspen. The rock surface is considerably rougher than that of the east beach. In general appearance this beach is much more like that about the camp at Siskowit Bay (V, 3) than the *Cladonia-procumbens* section, and contains more of the Low Juniper rather than the Procumbent Juniper. There is also much more exposed rock, and a much more diversified flora. In places the Low Huckleberries are very abundant, while they are not at all conspicuous on the eastern section. To get an idea of the general appearances *Figures 34 and 36* should be compared.

Figure 34 shows the marked dominance of *procumbens*, which was not abundant on the west slope. The plant life is more varied, with the foliaceous lichens and bunches of coral-like *Cladonia*, ferns, grasses, *Solidago*, and the willows and aspens in the crevices, *Fig. 37*. These forms give a very different aspect to the pioneer society from that of one composed of a *Cladonia-procumbens* mat. The open or patch like character of this society suggests that the retarded development of the vegetational cover may be related in some way to the scarcity of *J. procumbens*, which is such an excellent agent in soil formation. But why this shrub should not thrive here is not known.

Associated with these conditions were the snail *Polygyra albolabris*, and the grasshopper *Melanoplus fasciatus*. The absence of the dense mat, and less soil, greatly reduced the variety of animals frequenting such conditions.

Taking the station as a whole (V, 2), it is one of the most interesting places seen on the island. The beauty of the variegated Cladonia mat, the extensive area of the open habitat, the boreal character of the lichens, the Saxifrage and many of the shells, the apparent completeness of the preservation of the stages in the transformation from the lower beach back to the forest, all combine to make this situation one of the most interesting and important of those examined.*

Station V, Substation 4. Trail through Balsam-Spruce Forest. This station begins at the opening about camp (V, 3) and extends northwest to the south shore of Siskowit Lake, opposite the eastern end of an elongated island. The topography of the region traversed is one of low relief, with only occasional low rocks, hills, or ridges, 15 to 20 feet in height, and a few shallow and moist ravines. A thick layer of humus covers the surface, except on the ridges. The trail first passes through a forest of White Spruce, Balsam, Birch and scattered Tamaracks. Among these trees are many fresh windfalls, due to the winds and the shallow soil. In the more shaded portions the ground cover consists of a dense growth of mosses, liverworts, *Fig. 38*, with *Aster macrophyllus* in the less shaded portions. There are open patches 10 to 15 feet in diameter scattered about through the forest, especially on low rock ridges, which contain a growth of Cladonia, and illustrate the last stages of the decline of the openings.

In the moist depressions was found an abundance of Round-leaved Cornel, alder, and also Ground Hemlock, Mountain Ash, Balsam, White Spruce, and the Ground Pine (abundant.) There were many fallen and decayed logs. In and characterizing the more open places, such as were associated with large Birches, are the Large-flowering Rasp-

* This slope is very favorable for the study of the ecological distribution of lichens, and at this point attention is directed to some papers on lichen societies by Professor Bruce Fink, of Miami College. These are the most important papers on this subject.

1902. Ecological Distribution an Incentive to the Study of Lichens. Bryologist, 5, pp. 39-40.
1903. Some Common Types of Lichen formations. Bull. Torrey Bot. Club., 30, pp. 412-418.
1903. Some Talus Cladonia Formations. Bot. Gaz., 35, pp. 195-208.
1904. A Lichen Society of Sandstone Riprap. Bot. Gaz., 38, pp. 265-284.

Contributions to the Study of Lichens of Minnesota:

I. Lichens of the Lake of the Woods. Minn. Bot. Stud., 1, 1896, pp. 693-701.
II. Lichens of Minneapolis and Vicinity. Minn. Bot. Stud., 1, 1896, pp. 703-725.
III. The Rock Lichens of Taylors Falls. Minn. Bot. Stud., 2, 1898, pp. 1-18.
IV. Lichens of the Lake Superior Region. Minn. Bot. Stud., 2, 1899, pp. 215-276.
V. Lichens of the Minnesota Valley and Southwestern Minnesota. Minn. Bot. Stud., 2, 1899, pp. 277-329.
VI. Lichens of Northwestern Minnesota. Minn. Bot. Stud., 2, 1901, pp. 657-709.
VII. Lichens of the Northern Boundary. Minn. Bot. Stud., 2, 1903, pp. 167-236.

berry, Sarsaparilla (dominant), and *Clintonia borealis,* but *Aster macrophyllus* was not as abundant here as elsewhere. The larger Birches averaged about 12 to 15 inches in diameter. The general appearance of the conditions is shown in *Fig. 39.* This patch of birches was near the swamp (V, 5). From this Birch colony, on to the end of the trail to Siskowit Lake, the forest was dominated by large Birch, with a few quaking Aspen, Balsam and White Spruce, while in the damper places Ground Hemlock and Dogwood were abundant. On the ridges there are small "islands" of Cladonia, mosses, Bearberry and a ground pine. The general appearance of this forest, in an open place, is shown in *Fig. 40.*

While there are thus minor differences which prevent absolute homogeneity in the general conditions of the forest, yet these differences do not seem to particularly influence the environment as a whole. The general transition from the openings, as found on rock ridges like those about camp (V, 3), to the Balsam-Spruce forest may be seen by a comparison of *Figures 25, 26, 27 and 38.*

The fauna of the forest (V, 4) is rather varied. The shells are represented by *Acanthinula harpa, Zonitoides arborea,* and *Pyramidula cronkheitei anthonyi;* the beetles by the carabid, *Calathus,* the fungus-inhabiting beetles, *Boletobius, Tritoma* and *Grophaena,* and doubtless many of the other species which were taken about the flowers and the camp. The wood-boring Hymenoptera, as *Urocerus,* are also characteristic of this kind of forest. Hares remained concealed in the forests during the day, but at dusk they came in large numbers into the clearings to feed. The birds had begun to migrate when this location was examined, so that little attention was given to their habitat preferences.

Station V, Substation 5. Tamarack Swamp. This swamp lies between Siskowit Lake and the western end of the trail through the Balsam-Spruce forest (V, 4). This is a valley swamp bordering a small stream which flows through the swamp. The central open part of the swamp is occupied by a small pool or pond, *Fig. 41,* which is invaded by Yellow Waterlilies. Surrounding this is a zone of Buckbean and sedge, the overgrowing sedge being more conspicuous. This sedge zone is quite wet and quaking. The current of the stream passed through this zone and parted the sedges in a wet line two or three inches wide. At its outer border, the zone becomes invaded by small Tamaracks, 4 to 5 feet high, alders, willow, scattered Cassandra and Pitcher Plants, and Wild Rosemary (common). *Eriophorum,* the Blue Flag and the Purple Cinquefoil occur in some of the depressions. A very few small Arbor Vitae also occur here. A strip of trees bordered the stream, while farther south occurred the Cassandra and Sphagnum zone proper. The latter contained scattered Blue Flags, and upon dry hummocks, colonies of *Cladonia,* which seemed rather out of place. The margin of this area was invaded by the Tamarack, Black Spruce and Labrador Tea. The general appearance of this forest is shown in *Figs. 42-43.* Near the margin of the swamp, where the spruces are quite large and the ground well shaded, the growth of Labrador Tea and Sphagnum was very luxuriant. The growth of Sphagnum at this place was by far the most luxuriant seen upon the island. It grew in hillocks over fallen trees and stumps, and stood considerably above the general level of the swamp.

This ground cover was not limited to the swamp, but invaded the Balsam-Spruce forest in large billow growths, such as is shown in *Fig. 44*. In other places the undergrowth and ground cover of the Balsam-Spruce forest apparently invaded the swamp, as was seen by the intermingling of the two plant societies. Here there is a mat of the Sphagnum and Labrador Tea intermingled with Ground Cornel, *Clintonia borealis* and young Balsams. As in *Fig. 44*, this might also be interpreted to mean an invasion of the Balsam-Spruce forest by the swamp; but the vigor and dominance of the Balsam society favors the interpretation that this is an invasion of the swamp by the Balsam society. It is not surprising that along such a tension line either society may dominate at times.

The fauna of this bog consisted of a Garter Snake (*T. sirtalis*), found near the small brook flowing into the western or upper end of the bog. Here also was found *Hyla pickeringii, Rana clamitans,* and *R. cantabrigensis,* and a water strider, *Gerris,* running on the surface. In the Cassandra and Sphagnum hummock zone were found the grasshoppers, *Mecostethus lineatus, Melanoplus extremus,* and *Stenobothrus curtipennis.* Nearer the central lilypond, among the sedges and Cassandra, were found the dragon flies, *Tetregoneuria spinigera, Aeschna, Leucorhinia hudsonica* and *Sympetrum obtrusum,* and the spider *Epeira patagiata.* Through the central area of the bog the stream was only indicated by the parting of the sedges, but at the lower or eastern end it again became well defined, and contained the small Stickleback, *Eucalia inconstans.* Beetles taken from this bog were *Haliplus ruficollis, Hydroporus tristis* and *Agabus congener.* The molluscs were represented by the small bivalves, *Pisidium.*

Station V, Substation 6. South Shore of Siskowit Lake. This situation is simply the end of the trail through the forest, and marks the location of some collecting in the lake. The shore is rocky, with rather low and overgrown banks.

Station V, Substation 7. The Haytown Trail. This trail begins almost directly opposite the outlet of Siskowit lake, where a large White Pine has been marked "36 W. 65 N., 19 E." This area has been burned over, but farther inland the blaze on the older trees enables one to follow the trail. The course is shown by Lane, ('98, Pl. XI), but we examined it only to about the point where it is crossed by the outlet of Hatchet lake, at which place there was a Tamarack swamp with very large trees (V, 8). After crossing the burned area near Siskowit lake, this trail passed through dense Arbor Vitae bogs and a large area of Balsam-Birch forest. In general the area traversed was rather deeply covered with soil and contained very few rock exposures, those observed probably being due to fires.

The general character of the upland forest, of mixed conifer and hardwood, is indicated by the following list: Balsams, Birch and Aspens (all about 10 inches in diameter), scattered Arbor Vitae (10 to 15 inches), a few scattered White Pines (about 3 feet in diameter), and a few Hard Maples (some 8 inches). It is thus seen that the largest abundant trees are the White Pine, Arbor Vitae, Birch, Hard Maple and

Aspen. The large amount of hardwood present was an unexpected feature. This forest may be considered transitional between the Balsam, White Spruce forest, and the Hard Maple, Yellow Birch, Balsam and Arbor Vitæ forest as found on the Desor Trail (III, '04).

The undergrowth consisted of Ground Hemlock in abundance, Mountain Maple, Beaked Hazel, young Balsams and Birches. The ground cover was composed of *Clintonia borealis, Lycopodium lccidulum, Clabonia* on dry rotten wood, *Aster macrophyllus,* Large-flowering Raspberry and Wild Sarsaparilla.

Mountain Maples and young Balsams showed a marked tendency to take possession of the trail. The lack of an undergrowth in the dense swamps was particularly noticeable, and the clearly defined old trail through such places indicated relatively stable conditions.

A very marked characteristic of this trail was its limited fauna. Very few birds were seen, and Red Squirrels were not at all abundant. Several times we saw the remains of Balsam cones where a Red Squirrel had taken a meal. Almost no effort was made to collect invertebrates.

Station V, Substation 8. Arbor Vitae Swamp. This swamp marked the end of our Haytown Trail, and bordered on a small stream. The dark colored soil contained much humus and was soft and spongy. The vegetation bordering this stream was composed of Speckled Alder, Skunk Cabbage, Marsh Marigold, *Clintonia borealis*, scattered Blue Flags, and Ground Cornel; in the moderate shade, *Coptis trifolia*, Mountain Ash, young Arbor Vitae and Balsams, Twayblade, and, in the damp places, away from the stream, *Mitella nuda.*

In the dense and apparently well drained swamp there was a firm humic soil covered by a thick layer of leaves, conifer needles and twigs. The ground cover was composed of Ground Cornel, *Clintonia borealis* and Wild Sarsaparilla, with an undergrowth of Mountain Maple, Ciliated Honeysuckle, numerous young Balsams, young Arbor Vitae, Ground Hemlock, Mountain Ash, and Beaked Hazel. The large Tamaracks were about 3 feet in diameter, and the Arbor Vitae about 2 feet, others about 20 inches in diameter were abundant. It is thus seen that this was an old and mature swamp with some very large trees, under which the ground was quite open. With better drainage, the young or suppressed undergrowth would succeed the Tamarack society.

The old trail through this swamp was remarkably well preserved and distinct because the dominance of the large shade-producing trees prevented the development of an undergrowth. No animals were collected.

Station V, Substation 9. Outlet of Siskowit Lake. A trail or path ran from the head of the outlet of Siskowit Lake south to the Siskowit Bay beach, a distance less than a quarter of a mile. The area traversed had been burned, and second growth had developed, the best of which was in the depressions where the soil is deeper. The open ridges near Siskowit Lake, where the soil is thin, have an open growth near the head of the trail and support *Prunus pennsylvanica*, Birch, *Dierville dierville,* Mountain Ash, Mountain Maple, *Amelanchier oligocarpa,* Ground Cornel, Everlasting, Wild Rose, White Clover, Fire Weed and mosses. In the depressions among the underbrush in the deeper soil and in shade

is found *Diervilla diervilla*, Fire Weed, *Prunus pennsylvanica*, Mountain Maple, Mountain Ash, Birch, Mountain Alder, Willow, Sarsaparilla, Wood *Equisetum*, Oak and Ladies' Fern, Large-flowering Raspberry, *Cornus stolonifera* and *Clintonia borealis*.

The open arid character of much of this station is reflected in the grasshopper fauna, as follows: *Hibbiscus tuberculatus*, *Melanoplus alaskanus*, *fasciatus* and *Circotettix verruculatus*. The butterfly, *Basilarchia arthemis* was also taken here. The rare dragonfly, *Ophiogomphus columbrinus* was also taken at this station, probably because of the proximity of the rapid flowing outlet, which forms a trout stream.

Station V, Substation 10. Long Island Gull Rookery and Menagerie Island. This station was examined solely for its bird life, which will be discussed elsewhere in this report. This large Gull rookery is on Long Island, *Fig. 45*, which lies about one mile west of Menagerie Island where Isle Royale Light is located. This bird clearly breeds upon the middle and upper beaches. Long Island is formed by the upturned edges of red sandstone and is exposed to the full sweep of the lake waves, as is clearly evidenced by the bare rocks. The vegetation on the island was not examined, as the time that could be devoted to the examination of the rookery was limited. But mention should be made of the abundance of algae in the lake bordering the rookery, and of their abundance in the rock pools on the beach.

Station V, Substation 11. Tamarack-Spruce Swamp. This station includes a waterlily pond surrounded by zones of sedge, heath shrubs, Tamarack and Black Spruce. A general view of the pond is shown in *Fig. 46*. It was located almost due west of the western end of Station V, 2, and only a short distance northwest of the boat landing.

In the pond, submerged, was Utricularia, Yellow Waterlily, *Potamogeton*, and *Brasenia* (Water Shield); practically all the open water was occupied by the Yellow Water Lily. At the edge of the water grow the sedges, *Fig. 47*, which form a distinct zone, and the Buckbean. The sedge zone also includes the *Equisetum*, Purple Cinquefoil, *Comarum palustre*, a willow, *Hypericum*, Water Hemlock (*Cicuta bulbifera*), and the White Bog Orchid. Beyond the sedge zone comes *Sphagnum*, *Andromeda polifolia*, Cassandra, patches of Labrador Tea, *Oxycoccus oxycoccus* (Small Cranberry, abundant), Alder, *Chiogenes hispidula* (Creeping Snowberry), Bunch Berry or Dwarf Cornel (*Cornus canadensis*), *Kalmia glauca*, Pitcher Plants, *Drosera intermedia*. The trees do not extend to the inner limit of the Cassandra zone. Cladonia grew upon dry hummocks in this zone. In a few places, in depressions in the tree zone, Eriophorum was found. The trees are Tamarack, Black Spruce, and small Arbor Vitae. The general appearance of the Cassandra and tree zones are shown in *Fig. 48*.

The invertebrate fauna of this station was abundant and varied, but the vertebrates were more limited. In the Water Lily and Potamogeton zone the Stickleback, *Eucalia inconstans*, was taken, and at the sedge margin, *Rana clamitans*. Water bugs are represented by *Belostoma* and *Corixa* nymphs, and on the surface by the Water Strider, *Gerris rufoscutellatus*. A small shell, *Physa aplectoides*, was found in

small foot-print like pools in the outer part of the Buckbean and sedge zone. In the Cassandra zone were taken the dragonflies *Enallagma hageni, Aeschna, Leucorhinia proxima,* the grasshopper *Melanoplus alaskanus,* and the butterfly *Pyrameis cardui.* From this bog were also taken the Arachnids, *Lacinius ohioense, Drassus neglectus* and *Pardosa glacialis.*

The stations at Washington Harbor were not examined in 1905 in as much detail as were other localities, and the descriptions will therefore be correspondingly brief, and will be supplementary to a similar account by Ruthven, '06, pp. 48-52.

Station I, '04. Clearing at the Head of Washington Harbor. This clearing is the property owned by the Washington Club of Duluth, Minn. Much of it is sodded, pastured and under some form of cultivation. These conditions were particularly favorable for grasshoppers, which occur in great numbers. The following species were taken: *Stenobothrus curtipennis, Chloealtis abdominalis, C. conspersa, Mecostethus lineatus, Camnula pellucida,* and *Melanoplus alaskanus.* This area appeared to be a favorable resort for migrating birds, as shown in the accompanying report by Peet.

Station II, '04. Washington Creek. This is the small trout stream which flows into the head of Washington Harbor.

Station III, '04. Trail along the Top of the Greenstone Range, the "Desor Trail." This trail follows the road which has been opened from the Club House (I, '04) to Lake Desor (VII, '04). At the western end this road traverses a forest which varies considerably in its composition. In places it is dense and apparently original, but at one place it has been burned and replaced by an abundant growth of Birch. The original forest is dense and composed of large trees, and the proportion of hardwoods is surprising, since the Balsam-Spruce forest is so prevalent elsewhere upon the island. The hardwoods are really dominant. The forest *Fig. 49,* is composed of Yellow Birch, Balsam, Arbor Vitae, and a few Sugar Maples, and the undergrowth of Mountain Maple and Ground Hemlock. Farther out on the trail, toward Lake Desor, the Maple becomes dominant and forms an almost pure stand, so dense that in places there is almost no undergrowth, and the forest appears quite open with a scattered ground cover. A loose thick layer of leaves and twigs covers the forest floor. In the more open places the ground cover is composed of Large-flowering Raspberry, Wild Sarsaparilla, *Clintonia borealis, Lycopodium,* mosses, Ground Cornel, and the shrubs, Mountain Maple, Beaked Hazel, Round-leaved Cornel, Mountain Ash and Red Cherry. The Yellow Birch is a large tree, with a diameter of about 2 feet; White Pine is very rare, but the trees are large, even about 3 feet in diameter; Arbor Vitae reaches about 2 feet. A few Large-toothed Aspens, Black Oak and Black Ash were seen, the Aspens about 20 inches in diameter and the Maples 10 to 15 inches.

Red Squirrels were seen in the forest, the body of a Lynx was found hanging on a tree where it had been left by a trapper, and several Toads were seen. Invertebrate life was abundant. In an Arbor Vitae stump, galleries of an ant, *Camponotus herculeanus whymperi* (140 A), were

found in both the seasoned and the decayed wood. A few beetles were taken along the trail; *Quedius fulgides, Tachinus memnomius* and *Geotrupes blackburnii.* Shells were abundant: *Strobilops virgo, Vitrea binneyana, Euconulus chersinus polygyratus, Zonitoides arborea, Z. exigua. Pallifera dorsalis, Pyramidula alternata and P. cronkheitei anthonyi.*

Station IV, '04. Washington Brook. Cf. Ruthven, '06, p. 50. This station was examined on the slope back of the Club-house. It is a swamp forest along the border of a very small stream, *Fig. 50.* Part of the forest is being cleared.

Station V, '04. Tamarack Swamp. This swamp was not visited in 1905. Cf. Ruthven, '06, p. 50.

Station VI, '04. North Slope of Greenstone Range. Cf. Ruthven, '06, p. 49.

Station VII, '04. Lake Desor. Cf. Ruthven, '06, p. 51. A few additional records are: The dragonfly, *Enallagma exsulans*, the water strider, *Gerris remigis*, the fish, *Coregonus artedi.* At the end of the trail (III, '04) at Desor, the beetle, *Melanotus paradoxus,* and the spider *Dolomedes idoneus,* were taken.

Station VIII, '04. Western End of Siskowit Bay. The large clearing and burned area at the head of Siskowit Bay marks the site of a former town, the county seat. A well-defined graded road leads from near the north shore of the Bay westward and north to an old mining camp, This road is being invaded in places by Birches and Aspens. This extensive clearing was overgrown with many introduced plants and was given only a cursory examination. The following vertebrates were observed: Sharp-tailed Grouse, (of which several were seen), the Hare, Toad and Garter Snake. The snails, *Polygyra albolabris* and *Pyramidula alternata,* and the grasshopper *Stenobothrus curtipennis* were found here. The limits of this station were changed somewhat from those given in 1904.

Station IX, '04. Southwestern End of Minong Trap Range. Cf. Ruthven, '06, p. 51-52. No additional collections were made here in 1905.

Station X, '04. Washington Harbor. Cf. Ruthven, '06, p. 52. No additional collections were made at this station in 1905.

III. THE EVOLUTION OF THE GROSS ENVIRONMENT.

1. *Geological Succession.* In his report on the Porcupine Mountains. Ruthven ('06) has summarily outlined the general geological history of the Lake Superior region. It is only necessary, therefore, for our purpose, to repeat some of this history and to enlarge upon those phases peculiar to Isle Royale. The structural geology of Isle Royale has been studied in detail by Lane ('98) and is relatively simple. The different rock formations are in narrow strips nearly parallel with the long axis of the island, while the dip of the rocks is toward the basin of Lake Superior. The rocks north of Siskowit Bay consist of the truncated beds of ancient lava flows, interrupted by a small amount of interbedded sedimentary rocks. Although these tilted and truncated beds are

inclined at a high angle, this was not their original position; in all probability they were formed in a nearly horizontal position by fissure eruptions under the sea, because the lavas are interbedded with shales, sandstones and conglomerates. In thickness these lava beds vary from a few inches to hundreds of feet. The narrow beds often show upper and lower surfaces filled with small cavities (amygdules) in contrast with the denser central part. These cavities were formed by gas or vapor while the lava was hot, and leave such a rock porous and less resistant to disintegrating agencies and to erosion. The same principles also hold for the thicker beds of lava; the outer parts are more porous and softer than the central part. This structural difference is clearly shown in the topography of the island; the ridges mark the central or more resistant parts of the truncated lava beds, while the valleys, in general, have been worn into the softer outer parts of the lava and into the interbedded sedimentary rocks. These beds are of Keweenawan or pre-Cambrian age; their formation ceased with an elevation of the land from the sea and their destruction was begun by the agents of subaerial erosion. These processes continued until the titled strata were truncated and reduced to a base level. Again the region was depressed and upon this eroded surface were deposited unconformably those red sandstones and conglomerates which now characterize the Siskowit Bay region and to the southward, and are of Cambrian age. Once more the region was elevated, titled and subjected to prolonged erosion and the strata truncated as had been done with the Keweenawan. Similar processes continued until the marked elevation of the land, which took place at the close of the Tertiary, and which initiated the repeated glaciations of the Ice Age.

With the extension of the last or Wisconsin ice sheet in the Superior basin, Isle Royale was completely overridden by the movement of an ice sheet from the northeast that moved almost parallel to the ridges, but was somewhat more inclined from the east (Lane '98, p. 183). For this reason there was a tendency to plane down the southeastern slopes and to preserve the steeper ones which had been formed on the northwestern side (Foster & Whitney, '50, p. 202). As the island has a topography which indicates subaerial rather than marine erosion, it must have had at one time a residual soil, which, unless it had been swept away by a former ice invasion or the waves of some body of water, was probably removed at this time with the minor inequalities of the surface. In this manner the Superior lobe buried the island under several thousand feet of ice and continued its movement far to the southward, leaving a glacial desert in its wake. This condition of affairs lasted until the return movement broke up the great ice sheet into lake basin lobes and brought the receding ice front into the Superior basin. As soon, however, as this lobe wasted away from the margin of this basin, the water from the melting ice accumulated before it and formed a lake which, overflowing the rim, found its way through the St. Croix valley to the Mississippi river, as indicated in *Fig. 51.* But, as the ice

wall continued to retreat toward the northeast, these ponded waters increased in area and formed the highest beach lines now preserved on the north shore of Lake Superior. The evidence for this is found on Mt. Josephine, located on this shore just north of the southwestern end of Isle Royale, which reaches an elevation of about 800 feet above the Lake. Far up on its slopes, according to Lawson ('93, p. 253), evidence of beach lines are found, about which he says: "These two terraces at 585 and 607 feet are remarkable for being the highest strand lines which

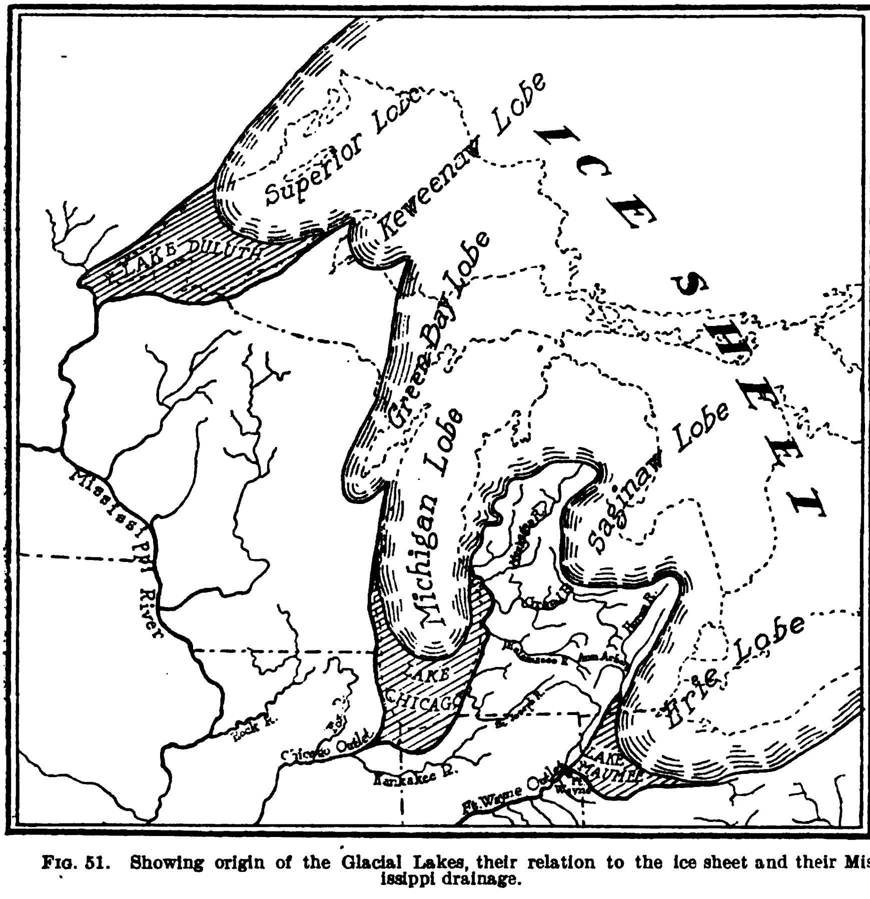

FIG. 51. Showing origin of the Glacial Lakes, their relation to the ice sheet and their Mississippi drainage.

have thus far been observed on the coast of Lake Superior." Under such conditions it seems that Isle Royale would undoubtedly have been submerged. The ice retreat continued and finally Isle Royale, freed from the ice and in part from the lake waters, emerged as a narrow rocky ridge—the crest of the Greenstone Range which today rises, at the northeastern end of the island, to a maximum elevation of about 550 feet. As the ice wall retreated the Michigan and Huron basins became confluent, and an outlet to the east (Trent valley, Ontario) at first, later the Port Huron and possibly the Chicago outlet (Goldthwait, '09, p. 65) became available, *Fig. 52*, and at about this time the Glacial Great

Lakes became isolated from the Mississippi drainage. The lake level was lowered, and it was perhaps at this level that the beach lines were formed on the north side of Lake Superior, which are now 400-500 feet above the present lake level (Taylor, '97, p. 126). Similar evidences of ancient beaches have been recognized by Lane ('98, pp. 188-191) upon Isle Royale, but he is inclined to place the level of this Glacial Lake Algonquin at about 485 feet. It is probable that more field work will be necessary before adequate correlations of these beaches can be made.

Some general idea of the extent of the island at this stage may be gained by reference to the 460 foot contour on the accompanying map,

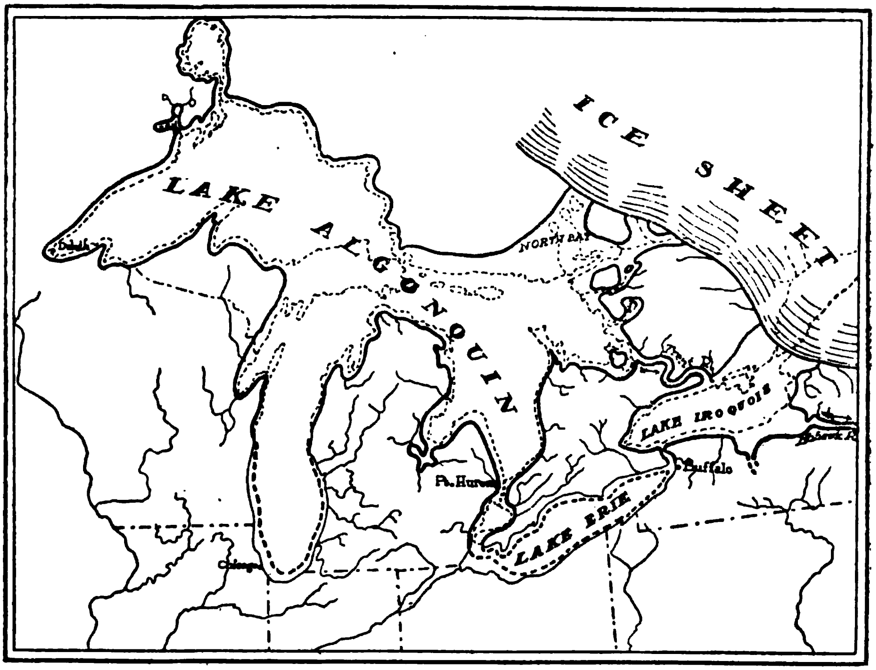

FIG. 52.—Showing the Algonquin stage of the Great Lakes. A water barrier to northward dispersal of the land biota.

Fig. 53. At this time, *Fig. 52,* the ice sheets had retreated far enough to the northeast that the climate of the Superior basin must have been so greatly ameliorated that animal life could have lived in its water. This inference seems probable because fossil shells have been found in the beach lines of the same lake farther to the south by Lane and Walker (Lane '00, pp. 248-252), and at Port Huron, Michigan by the writer in company with Dr. J. W. Goldthwait and Dr. A. G. Ruthven (Goldthwait, '07, p. 118). Here were found an abundance of *Goniobasis livescens,* occasional valves of *Sphaerium striatimum* Lam. and Unionid fragments, a fauna like that of the present beaches. It is therefore not improbable that this fauna invaded the Great Lakes drainage from the Mississippi during the early stages of the great glacial lakes, when they still overflowed into the Mississippi drainage.

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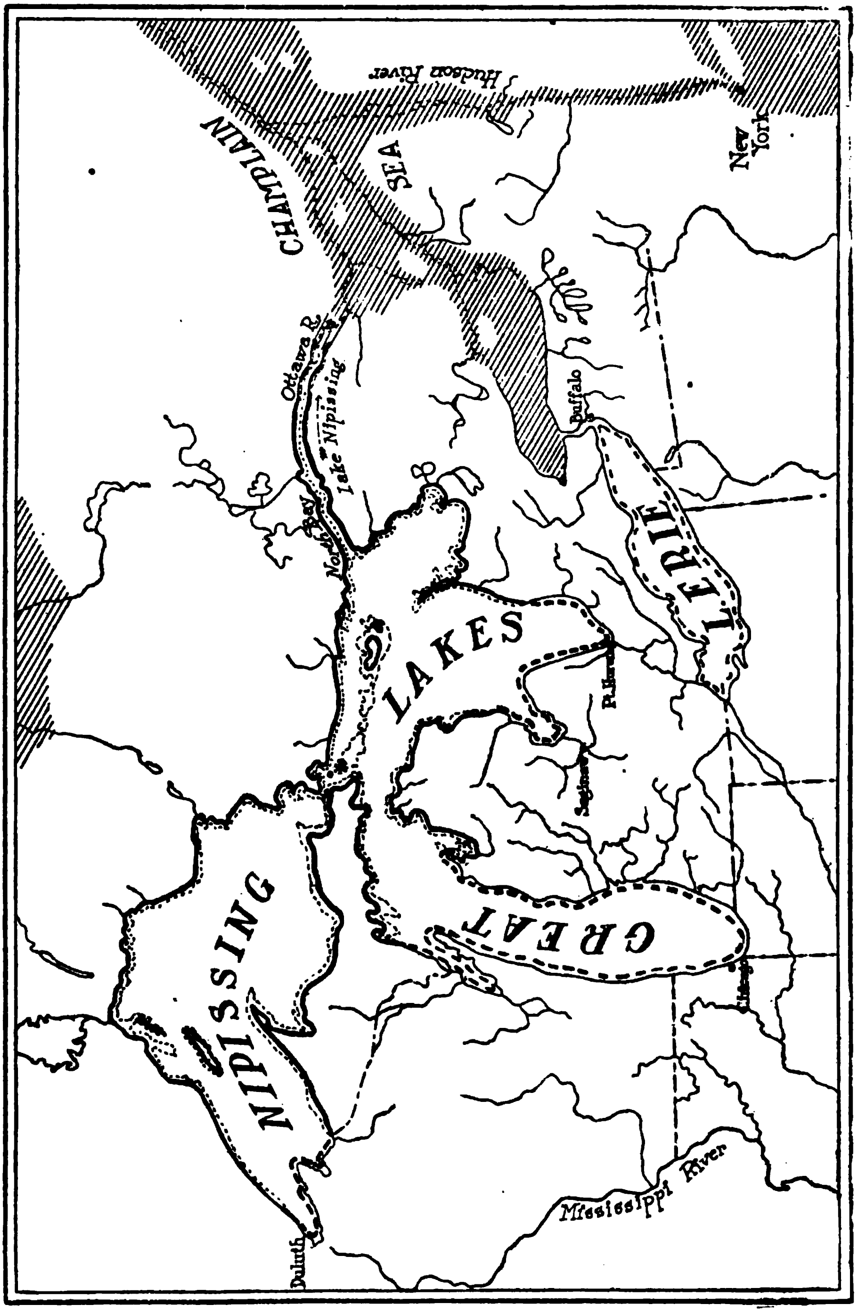

FIG. 54. The Nipissing Great Lakes. Showing the fresh water highway or barrier in the west and the sea barrier in the east.

and thus the salt water was excluded. An alternative hypothesis is that these animals are adapted to a constant and low temperature rather than to fresh or salt water, and that during Glacial times they were dispersed far to the south in fresh water and have only been preserved in restricted favorable localities. The low temperature of Glacial times would be a period especially favorable for the acclimatization of marine forms to fresh water on account of the favorable conditions which accompany the slow rate of changes at low temperatures.

The long duration of the Nipissing Great Lakes is well attested by the character of the beach. As Taylor ('96, p. 398) remarks: "It is altogether the most remarkable littoral feature of the Great Lake region. It is a shore line well advanced towards old age. All other beaches of the lakes are youthful in comparison .... Instead of the slender spits and barrier bars of the Algonquin and other beaches, the Nipissing beach has what may be called barrier plains, made up of many, sometimes forty or fifty, massive beach ridges laid one against the other. Many bays were entirely filled by these beach plains and others were cut off, so as to form small littoral lakes. Some of these plains are a mile to a mile and a half wide. In some instances the old deltas of other beaches are large and conspicuous, but the constructive products of wave action have no comparison to those of the Nipissing beach." From a biological standpoint these facts are of special significance. The maturity of the beach line is a condition decidedly favorable to the development of a littoral biota. The sandy shore, spits, bars, beach pools, cut-off ponds and lakes furnish a variety of favorable habitats in marked contrast with the poverty stricken character of life frequenting an exposed and topographically youthful lake shore. Such an old beach is both qualitatively and quantitatively favorable to the biota, and not only favors an abundant supply but also its dispersion along shore and by currents throughout such a body of water. The long duration of such conditions is of evident advantage to an extensive dispersal of such life.

As the basin of the Nipissing Great Lakes in the Superior basin was so much like that of Lake Superior, it is not improbable that the lake currents were much the same in both lakes, so that our knowledge of the present lake currents should aid in the interpretation of those of the Nipissing Great Lakes. Such relations as these suggest that at the Nipissing stage, and perhaps even earlier, the lake currents tended to people Isle Royale with north shore drift. By this time the island was quite large, though smaller than the present island by the subtraction of the area below the 60-foot contour. At this time the climate of the region must have become greatly ameliorated so that the north shore of Lake Superior was perhaps repopulated from the south, largely around the western end of the lake. With the advent of an abundance and diversity of plant and animal life, a new element enters the environment, whose influence is far reaching. The vegetation tends to blanket the surface with a humus layer and thus to bind the soil so that it retards erosion and becomes a geological agent. The influence of animal life is also far reaching and may be conspicuous if beavers are abundant. But these influences will only be mentioned here.

The development of the Nipissing beach upon Isle Royale has not

been so clearly recognized as elsewhere. Thus Lane ('98, p. 187) considers the present beach as the most distinct of any found upon the island. In a way this is not surprising when we recall the fact that at former lake levels the small area of the island did not permit of an extensive stream development, hence the limited quantities of sand, gravel and boulders. Thus the overriding of the ice, the isolation of the island in deep water, and the steep shores of resistent rocks are conditions unfavorable for supplying tools with which the waves could work. All of these conditions would tend to preserve the youthful topographic features and exaggerate the apparent relative rate at which the island emerged from the waves and the small time during which the waves beat at any particular level. The materials available to the present waves have therefore been cumulative. Lane ('98, pp. 188-189) has recognized several evidences of a 60 foot level.

After the formation of the Nipissing beach there was an uplift toward the north, as shown by Taylor's ('97, p. 127) study of this beach on the Canadian shore north of Isle Royale. In the vicinity of Port Arthur this beach is at 60 feet; at Nipigon 90 feet, and 110 to 115 at Peninsula Harbor. Such an assumed variation or tilting near Isle Royale suggests the necessity of great caution in attempting to correlate the various beaches and emphasizes the desirability of further field work upon this subject. Lane ('98, p. 192) suggests that this northward tilting has tended to pond the northeastward flowing streams and to drain the ones flowing in the opposite direction. Such tilting as this would have considerable influence upon the biota. Even in an uplift of a few feet per mile, in the case of Isle Royale 45 miles long, would be sufficient to have a marked influence upon the swamp environment, which is one of the most characteristic features of the island. In this manner a swamp and its biota might migrate several miles, become a pond or lake or even become drained, and other fates are suggested for ponds, lakes and other environments when such a distinct trend or dynamic tendency is present in a given region.

The change from the Nipissing to the present lake level was not a sudden one, as Lane ('98, p. 191) has recognized beaches at various levels showing its gradual character; the 30 and 15 foot levels are, however, the most distinct. A few observations were made upon two of these abandoned beaches, but their height was not determined. One was located just south of the mouth of Conglomerate Bay in a small cove about 60 or 70 feet wide. There was an abundance of fresh drift wood a few feet from the edge of the water, back of this a zone of weathered and decayed drift, and beyond this a high boulder beach containing disintegrated boulders with foliaceous lichens, while back of the lichen zone came Wild Cherry, Paper Birch, Bear-berry, Wild Rose, Jack Pine, Alders and Columbine. The back slope then declined into a Jack Pine growth. This beach is interesting because it illustrates the various stages from wave-washed, clean sand and gravel back into the forest growth. Lane ('98, p. 185) refers to a lichen covered beach on Sec. 10, T. 65, R. 34. The second of the beaches mentioned is located on the south shore near the eastern end of Siskowit Bay (Sec. 26, T. 65 N., R. 35 W.). The present beach is locally known as the "Greenstone beach" and forms a good boat landing.

2. *The Topography and its Origin.* The most conspicuous and characteristic topographic features of the island are its parallel flat-topped rock ridges with the intervening valleys and numerous swamps. These ridges project far out from the main body of the island and form the narrow rock ridges bounding the harbors, and forming a vast number of small islands and low rocky reefs. The tilting, faulting and truncation of these narrow beds clearly shows that the dependence of the topography upon rock structure is one of the most characteristic features of the island.

The main ridge, the Greenstone Range, is a divide which extends the entire length of the island, and is from about 400 to 500 feet high, with a maximum height of about 550 feet at the northeastern end of the island. At only one place does a drainage line cross the Greenstone. This is a small stream heading in Sec. 17, T. 64 N., R. 37 W. and a tributary to Washington River. This ridge is a truncated lava bed whose outer softer part has been eroded, thus throwing into prominence the compact resistant central core. Thus erosion, faulting and the dip of the rocks have combined to produce a northwestward facing escarpment nearly throughout its extent. The fairly flat topped truncated ridges of the island clearly show that their origin must be due to a period of baseleveling and is no doubt related to those extensive processes which have produced the Laurentian peneplain (cf. Ruthven, '06, p. 45) of the Superior region. The ridge of second importance is the Minong Trap Range, which lies parallel with the Greenstone, about a mile to the northwest, and reaches a height of about 400 feet. Between these ranges lies a valley containing five fairly large lakes, all of which drain across this range to the northward, and the probable faults indicated by Lane ('98, pl. 1) at Todd Harbor and McCargoe Cove are suggestive as to how the ridge has been broken through. Faults seem to have influenced the location of several lakes, such as Angleworm, Lesage, Livermore, Chickenbone, Feldtmann and also the outlet of Lake Richie into Chippewa Harbor. In addition to these main ranges there are great numbers of lower ones whose heights range from 100 to about 300 feet. East of Lake Feldtmann there is a bold escarpment 130 feet high, which was said by McIntyre (Foster, '50, p. 506) to afford the "finest view that I have seen on the island."

The drainage of the island presents some interesting features. At each end of the island the drainage is mainly along the valleys into the harbors at their ends. Between these two extremes, roughly marked by the area between lakes Desor and Sargent, the drainage, although it may follow the valleys for some distance, is yet to a marked degree across the strata or ridges. Taken as a whole the drainage is very imperfectly developed. Although the island is not extensive, it contains numerous small independent streams which drain into the lakes or directly into Lake Superior, but it has no master stream. It seems probable that this is also related to faulting, as also in the case of the stream, which may be called Malone Creek, that flows into the head of Siskowit Bay. The probable influence of faulting upon the location of lakes has previously been mentioned, and combined with its influence upon streams reinforces the idea of the dominance of structure upon the topography and consequently upon the drainage. But when in the

field the most conspicuous features of this imperfect drainage are the vast strips of swamp land found in the valleys and bordering the lakes and streams. The rock bound character of the basins and the southward tilting of the surface must greatly influence the form and extent of these strips. The stream channels have not cut deeply but are largely bordered by swamps, and the divides between many of them are very low or may even be swamps, so that the drainage from either end of a swamp may be into a different drainage line. Such imperfection of the drainage means that evaporation rather than run off is the pronounced feature, and this condition, combined with the insular location, must greatly influence the relative humidity of the atmosphere. The brownish waters of even the largest lake upon the island, Siskowit, 54 feet above Lake Superior, clearly shows the influence of the imperfect drainage and the extensive swamps of its drainage basin.

The general character of the soil was indicated by Ives on the Linear Survey map. This is as a rule shallow, the deeper being at the southwestern end (T. 64 N., R. 38 W.) and is characterized as "sandy loam and stony, second rate sufficiently deep for cultivation." At the head of Siskowit Bay (T. 63 N., R. 37 W.) he records soil "stony, 2nd and 3rd rate land. Soil varies from a few inches to 3 or 4 feet in depth." And near McCargoe Cove (T. 66 N., R. 35 W.) the soil is from 1 to 10 feet deep. The soil then in general may be said to be shallow, second and third rate stony, sandy loam. In the swamps and valleys there is a large amount of vegetable debris, although it is probable that this is generally not deep. No bog lime or marl has been observed. Large strips of the ridges are destitute of soil, especially those which have been burned. No morainic materials were recognized, although the ice overrode the island, and glacial boulders are abundant in places, as about the head of Washington Harbor. Dr. Lane writes me that there is some till, "especially on the lee end near Washington Harbor."

The origin of these soils appears to be relatively clear as there are only a few possibilities available. Some of the pre-Glacial residual soil may have been preserved but it has not been recognized. As above mentioned there are some Glacial boulders and till. The post-Glacial disintegration and decay of the rocks has been the most important source, supplemented by organic remains, from the vegetation in particular. A fourth source is the lake deposits of sand and clay as the waves have worked over the entire surface. These are best preserved in what were once harbors or places protected from the waves. In many localities the origin of the soil is diverse, several different processes having contributed a part.

From the above topographic relations it is seen that the flat-topped ridges and depressions are due to the structure of the rock, the influence of base leveling processes and probably also to faulting. The present drainage is not sufficient to explain the primary ridges and valleys; these must therefore have been inherited from past conditions. The present drainage is therefore consequent and in its infancy, hence its imperfection. From a biological standpoint these facts are significant because such conditions favor isolation of small streams, swamp and lake habitats affect the relative humidity and produce a prominent zonal and linear arrangement of the habitats along the ridges and

valleys. The absence, residual, or organic character of the soil is also an important factor of the environment.

3. *The Atmospheric Influences and their Evolution.* a. *Climate.* Unfortunately there has been no continuous series of climatological records made on Isle Royale. A few records were made by our party with instruments loaned by Mr. C. F. Schneider of the Michigan Weather Service, that, while very imperfect, are suggestive. The mean temperature for 26 days in July is 58° F., the minimum record is 46°, and the maximum 79°. From August 2 to 17 the mean is 59°; the mean maximum is 71° and the mean minimum is 47°. For the same period the maximum is 80° and the minimum 36°. There was but little rain although it rained all day on July 15.

Very fortunately, however, these meager records may be supplemented by those from Port Arthur, about 25 miles distant on the Canadian shore.[1] This data has been kindly furnished by Mr. B. C. Webber of the Canadian Meteorological Service. The records cover the decade of 1896 to 1905, and show the mean monthly and annual temperatures, maximum and minimum temperatures, and the precipitation for the same period.

The table of temperature, Table 1, shows that the decade average of the mean monthly temperatures for February is 7.65° F., with a maximum during July of 62.24° and an average annual of 36.07°. The monthly averages of the maximum temperatures for January is 38.1° and for July 85.8°, with an average annual of 36.7°. The lowest average monthly temperature for the same period is—27.5° for January, and for July 42.0°. The average minimum temperature for this ten years is—30.8°. The monthly averages for 5 months are below zero.

TABLE NO. 1.—MEAN, MONTHLY AND ANNUAL TEMPERATURES AND AVERAGES FOR 10 YEARS. PORT ARTHUR, 1896–1905.

Mean Temperatures in °F.

Year.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Ann'l mean.
1896	9.3	12.4	15.9	35.5	51.6	59.8	63.5	60.2	51.0	38.5	19.7	16.0	36.1
1897	6.9	13.2	19.5	36.1	46.5	53.7	64.0	59.6	57.0	44.4	23.1	11.3	36.3
1898	10.4	10.6	24.2	35.5	47.9	54.5	60.4	59.6	55.9	41.7	28.1	12.2	36.1
1899	3.2	1.4	9.9	36.3	46.6	55.9	61.8	60.8	48.8	44.3	36.7	14.3	35.0
1900	14.8	1.5	16.6	40.6	50.8	57.9	61.9	63.5	54.7	49.3	25.1	17.2	37.8
1901	7.6	5.6	17.8	38.3	49.2	56.8	64.0	62.1	52.6	42.3	24.7	12.1	36.1
1902	10.9	15.0	27.5	35.8	46.7	52.6	63.2	58.9	50.2	40.6	30.7	11.7	37.0
1903	7.8	7.9	24.0	35.2	46.4	56.9	61.8	57.3	50.0	43.4	26.0	7.5	35.4
1904	4.4	0.5	18.4	33.3	47.4	55.5	60.4	58.4	50.2	41.0	30.9	10.1	34.2
1905	4.4	8.4	21.6	35.3	45.8	54.6	61.4	61.4	54.6	40.3	26.9	18.7	36.1
Average	7.97	7.65	19.54	36.19	47.89	55.82	*62.24*	60.18	52.5	42.58	27.19	13.11	*36.01*
S. E. Michigan (Mean)	24.1	22.2	30.8	46.9	56.7	67.1	*71.9*	69.1	62.6	50.6	36.5	27.0	*47.2*

[1] For a general account of the Canadian climate see Stupart '98 and '05.

Highest Temperatures in °F.

Year.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Ann'l min'm
1896	36.0	47.0	47.0	59.0	89.0	88.0	91.0	87.0	77.0	66.0	46.0	47.0	91.0
1897	42.0	33.0	45.0	67.0	73.0	86.0	84.0	83.0	88.0	74.0	47.0	38.0	88.0
1898	35.0	38.0	43.0	60.0	76.0	80.0	85.0	82.0	78.0	64.0	61.0	43.0	85.0
1899	38.0	42.0	32.0	74.0	78.0	81.0	86.0	82.0	78.0	67.0	60.0	43.0	86.0
1900	46.0	32.0	54.0	66.0	84.0	83.0	86.0	82.0	78.0	68.0	57.0	40.0	86.0
1901	36.0	38.0	44.0	67.0	77.0	85.0	90.0	85.0	82.0	70.0	48.0	37.0	90.0
1902	35.0	41.0	49.0	69.0	81.0	76.0	83.0	80.0	71.0	64.0	53.0	34.0	83.0
1903	34.0	43.0	48.0	61.0	71.0	85.0	87.0	82.0	76.0	63.0	69.0	34.0	87.0
1904	37.0	33.0	41.0	66.0	81.0	80.0	84.0	81.0	70.0	65.0	48.0	44.0	84.0
1905	42.0	41.0	54.0	67.0	77.0	77.0	82.0	79.0	73.0	77.0	52.0	39.0	82.0
Average	*38.1*	38.8	45.7	65.6	78.7	82.1	*85.8*	82.3	77.1	67.8	54.1	39.9	*86.2*

Lowest Temperatures in °F.

Year.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Ann'l ma'xm
1896	-33.0	-26.0	-18.0	6.0	31.0	38.0	41.0	34.0	23.0	14.0	-21.0	-24.0	-33.0
1897	-30.0	-26.0	-15.0	2.0	26.0	28.0	50.0	37.0	25.0	20.0	-11.0	-21.0	-30.0
1898	-19.0	-26.0	-3.0	1.0	30.0	36.0	37.0	40.0	30.0	14.0	-11.0	-30.0	-30.0
1899	-37.0	-37.0	-17.0	8.0	27.0	37.0	43.0	41.0	20.0	24.0	-14.0	-22.0	-37.0
1900	-24.0	-30.0	-16.0	18.0	25.0	34.0	41.0	44.0	31.0	28.0	-4.0	-25.0	-30.0
1901	-25.0	-20.0	-26.0	16.0	29.0	32.0	42.0	40.0	28.0	20.0	0.0	-29.0	-29.0
1902	-30.0	-18.0	-11.0	5.0	23.0	34.0	44.0	39.0	25.0	21.0	-6.0	-20.0	-30.0
1903	-22.0	-31.0	-10.0	2.0	16.0	34.0	40.0	37.0	29.0	21.0	-8.0	-26.0	-31.0
1904	-34.0	-26.0	-13.0	12.0	25.0	37.0	40.0	35.0	30.0	20.0	-1.0	-23.0	-34.0
1905	-21.0	-24.0	-16.0	16.0	24.0	35.0	42.0	33.0	28.0	10.0	-12.0	-11.0	-24.0
Average	*-27.5*	-26.4	-14.5	8.6	25.6	34.5	*42.0*	38.0	26.9	19.2	-8.8	-23.1	-30.8

The precipitation during the same period is shown in Table 2. The minimum average monthly rainfall for the period is .002 inches for February, with a maximum of 4.25 inches in July, and an annual total of 21.73 inches, more than half of which fell during the growing season for the vegetation—June, July and August. The snowfall averaged a maximum for January with 4.59 inches and an annual total of 25.44 inches. The deep snows of this region are thus seen not to be due so much to the abundant precipitation as to its preservation by the low temperature.

TABLE NO. 2.—PORT ARTHUR, 1896–1905.

Rainfall.

Year.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.
1896	0.00	0.00	0.12	2.32	4.10	2.04	1.75	1.73	1.41	3.04	1.28	0.00	17.79
1897	0.57	0.00	0.00	0.64	2.06	3.39	6.53	4.65	1.12	1.44	0.57	0.00	20.97
1898	0.00	0.00	0.33	0.07	3.04	6.94	4.58	2.42	5.40	2.78	0.65	0.00	26.23
1899	0.00	0.00	0.00	2.57	3.40	3.84	3.52	3.76	3.65	1.79	1.34	0.78	24.65
1900	0.00	0.00	0.00	0.50	0.36	2.48	3.33	6.77	6.14	5.20	0.49	0.12	25.39
1901	0.00	0.00	0.00	1.57	0.95	3.76	6.24	2.92	1.98	2.47	0.38	0.00	20.27
1902	0.00	0.02	0.36	0.55	1.89	5.18	3.03	3.01	1.99	2.78	1.29	0.00	20.10
1903	0.00	0.00	0.14	0.23	3.14	1.60	3.29	1.97	5.56	2.61	0.27	0.00	18.81
1904	0.00	0.00	0.36	0.32	2.37	2.36	2.94	2.65	3.41	3.62	0.15	0.06	19.24
1905	0.00	0.00	0.88	0.69	2.14	2.36	7.33	1.30	4.58	2.27	2.29	0.00	23.84
Average	.057	*.002*	.22	.95	2.35	3.39	*4.25*	3.12	3.52	2.8	.87	.09	*21.73*
S. E. Michigan	*1.94*	2.16	2.42	2.27	*3.53*	3.19	2.68	2.38	2.30	2.73	2.88	2.03	*30.22*

Snowfall.

Year.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.
1896	5.5	2.1	6.4	6.8	......	......	......	......	......	1.1	13.4	1.6	36.9
1897	1.6	8.6	9.2	8.1	......	......	......	......	......	*	4.9	4.6	37.0
1898	5.1	4.6	5.4	......	......	......	......	......	......		1.2	2.8	19.1
1899	5.0	5.7	3.4	*	......	......	......	......	......	......	......	4.7	18.8
1900	8.5	2.0	2.9	......	......	......	......	......	......	......	1.8	1.8	17.0
1901	8.4	0.6	6.6	......	......	......	......	......	......	......	3.3	3.5	22.4
1902	5.0	2.4	0.4	*	......	......	......	......	......	......	4.8	4.6	17.2
1903	2.3	2.9	8.1	15.8	0.3	......	......	......	......	1.0	0.8	1.8	33.0
1904	2.3	1.8	7.8	0.4	......	......	......	......	......	......	4.3	13.7	30.3
1905	2.2	2.9	5.5	6.3	......	......	......	......	......	0.7	4.1	1.0	22.7
Average	4.59	3.37	5.57	7.48	0.3	......	......	......	......	.93	4.28	4.01	*25.44*
S. E. Mich. (5 years)	......	......	......	......	......	......	......	......	......	......	......	......	*38.4*

These climatic records are likely to mean little when taken by themselves, but when compared with the conditions found in the other extreme of the state, interesting relations become apparent. Transeau ('05 b, pp. 356-358) has summarized the temperature and precipitation means for certain localities in southeastern Michigan, and these means have been placed in the table with the Port Arthur data. The most striking difference (Table 1) is the much higher temperature throughout the year in southern Michigan; the mean July maximum is 71.9° as contrasted with 62.24° at Port Arthur; the annual mean is 47.2° as contrasted with 36.07° for Port Arthur. The northern mean is between the temperature of the maximum density of water (39.2°) and the freezing point. The precipitation presents almost equally striking differences. The rainfall instead of being largely confined to the summer months, as at Port

Arthur, is much more generally distributed throughout the year. The rainfall is also about ⅓ more in the south, the northern mean is 21.72 inches and the southern one 30.22 inches. In the north there is about 1/5 more snow than rainfall, 21.72 as contrasted with 25.44 inches; while in the south about ¼ more of the precipitation occurs as snow, 30.22 of rain as contrasted with 38.4 inches of snow. While in both regions the greater precipitation is in the form of snow, the longer growing season of the plants in the south makes more of this moisture available; but on the other hand, on account of the higher temperature, more is needed. While about one-half of the rainfall in both regions occurs during the growing season, yet the evaporation is much greater in the south so that the relative humidity is less when compared with the north. (Cf. Transeau, '05, a). It seems probable that the relative humidity of Isle Royale is greater than on the adjacent mainland on account of its insular location and imperfect drainage.

Mention should also be made of the long period of daylight in the north because this is of great importance to a vegetation whose period of growth is limited to such a short summer.

To one accustomed to the hot summers farther south, the cool summer of Isle Royale is very agreeable and invigorating. Moderately heavy clothing is needed for comfort except during the middle of the day when the heat at times is very oppressive. This was especially the case during our examinations of the rock ridges. Thus on July 10 on the Jack Pine Ridge (III, 5) the thermometer on a mat of Cladonia recorded 93° F. in the sun, while at the same time (2 P. M.) in the sun, but exposed to a cool breeze, it recorded 76° F. Such temperatures would not attract special attention were it not for the fact that usually the temperature is so much lower. The nights are very cool, and at Washington Harbor on Aug. 22 there was a frost in the valley along Washington Creek (II, '04). During our camp at the Light-house, when shore winds accompanied a storm, the temperature became so low that a fire in the evening was necessary for comfort. On July 15 there was a brisk east wind, with a mean temperature of about 50° so that the vapor of ones breath was visible all day. The lake breeze is at times very noticeable as one passes from Rock Harbor into the channel at Middle Islands. It is quite probable, as Jackson ('50, p. 420) suggests, that this cold lake air is a factor in the production of the stunted tree growth.

The low temperature of the wet, densely forested cedar swamps is worthy of special mention. As Foster remarks ('50, p. 420) "Under the shade of the crags, and among the thick evergreen swamps of white cedar, it not unfrequently happens that perennial ice is found, covered by a layer of turf. Mr. Blake discovered a considerable area of ice thus preserved in midsummer, near Rock Harbor." Unfortunately our party did not find such conditions although such "cold islands" were kept in mind with the idea that under such conditions "glacial relicts" might be expected if these areas were of sufficient extent.

b. Seiches. The rapid and temporary changes of the water level in the harbors has been the basis of much comment. This was very marked at Tobin Harbor and at Washington Harbor. Its influence upon Washington Creek was quite marked, at times it would be ponded for some distance up stream while on other days it would be a briskly flowing

stream. Foster and Whitney ('50, p. 51) make the following comment upon these fluctuations at Rock Harbor; "While at Rock Harbor, Isle Royale, in the summer of 1847, we witnessed the ebbing and flowing of the water, recurring at intervals of fifteen or twenty minutes, during the entire afternoon. The variation was from twelve to eighteen inches; and we took advantage of their recession to catch some of the small lake fish which were left in the pools. The day was calm and clear but before the expiration of forty-eight hours a violent gale set in."

This phenomenon has been investigated on the Great Lakes by Denison ('98, p. 568) who states that these seiche movements are very marked preceding and during storms and are due to atmospheric pressure upon the lake.

c. Climatic Succession. From what is known of the general geological history of the Superior region, during Glacial and post-Glacial times, it is evident that there has been a great climatic change which has been of the utmost biological importance. It is therefore desirable to see what inferences will aid us in forming a general conception of the possible climatic successions. It appears to be generally conceded that at the margin of the ice sheet the conditions must have been quite arctic in character, similar to that of the "barren grounds" of the far north. Such climatic conditions might result from a permanent atmospheric low correlated with the presence of the ice sheet (Cf. Chamberlin and Salisbury, '06, 11, pp. 674-675; 111, p. 433). The prevailing westerlies, combined with a permanent low to the north would favor westerly continental winds along the margin of the ice. Perhaps a suggestive comparison can be made between the seasonal transitions from the two permanent winter lows near the Arctic regions, into the summer condition of one low with its transitional "March weather" and that of American and European glacial lows and their transformation into the present summer arctic low. In connection with this subject a paper by Fassig ('99) is of special interest. Analogies are often dangerous but the idea is of interest because it suggests a "March weather" transformation for post-Glacial times. In this connection the formation and occurrence of the wind blown loess, with its greatest development in the west and on the east banks of certain streams, is of special interest, although these conditions did not develop in the north as they did farther south. The occurrence of the westerly winds seems to be further supported by the westerly and southwesterly extension of the ice from the centers of the accumulation (Cf. Chamberlin and Salisbury, '06, 111, pp. 330-333). Somewhat similar conditions in some respects obtained in Europe (Penck, '06, p. 183) but the dry winds were easterly rather than westerly as in North America. The European loess deposits also approached much nearer to the (western Europe) coast than in America, where they remain far to the interior. The Great Lake storm track may have been wider, but, more probably, was narrower and more intense. The northeastward retreat of the ice sheet is paralleled by the northeastward migration of spring weather conditions (Bigelow, '97, p. 48) and if this route of the opening of spring was initiated at this early date it must have had important biological consequences upon the migrating animal life of the interior. The arctic and storm track types of climate are perhaps the only ones which Isle Royale has possessed, although the storm centers

may have, as a rule, passed farther south than at present. If these suggestions are applied to the interpretation of the Glacial and post-Glacial history of Isle Royale, the general relations will be about as follows: Succeeding the disappearance of the ice was an arctic condition with short summers and long winters, prevailing westerly winds, and severe easterly or southeasterly moving storms. Such conditions as these would influence the direction of lake currents, wave action on the beaches, and the source and movement of the lake drift, all of which would greatly influence the biota.

If the Glacial and post-Glacial adjustment of the permanent lows was accompanied by severe storms, this would be a factor which would certainly influence the rate of formation and the distinctness of the beach lines, and it is not altogether improbable that a study of the well developed Nipissing beach, by the development of its spits and bars, may furnish data regarding the lake currents and the prevailing winds. But in order to interpret such records it will be necessary to formulate criteria by means of which duration of a beach formation may be distinguished from one of less duration but due to more severe storms and active currents.

d. *The Lake Storms and their Influence.* The significance of lake storms is of special interest on account of the bearing of the latter upon the conditions of life upon the beach, and also upon the lake drift. That they must be reckoned as an important factor in the post-Glacial repopulation of Isle Royale is evident when we recall that during the life of the present fauna and flora the island has never been connected with the mainland except by ice. Very fortunately the subject of lake storms has been carefully investigated by Garriott ('03) because of its influence upon navigation.

The period of greatest seasonal frequency for severe storms ranges from September to December, with a November maximum, while March contains the greatest number of such storms for the remainder of the year. The smallest number occur in June, July and August.

There are several types of these storms, the most severe of which are those of southwestern origin and which occur between October and May. They are preceded by east and northeast winds which gradually become a gale; but when once the storm center has passed the wind suddenly shifts to the northwest and is an offshore wind from Canada. Such storms are frequently followed by much snow and intense cold. During the warmer months, storms from this direction are usually of tropical origin.

Less severe storms are those coming from the middle-west. These are preceded by gales, first from the south and later from the east, and after the passage of such a storm center the wind suddenly changes to the northwest and finally finishes with clearing weather, or if in winter, sometimes by a light snow. These storms are common at all seasons of the year, but the most severe ones occur during the cold months.

Storms from the northwest are seldom severe; they are preceded by south or southwest winds, and after their passage the wind shifts to the west and northwest and rapidly diminishes in velocity. In winter the attending precipitation is generally light, in summer it is in the "form of thunder storms, and the high winds in squalls from the southwest

at the time the center of the storm is passing." To this class belong the majority of lake storms, but they are seldom severe.

From these relations it is seen that storms whose origin is from the south, southwest or middle-west, are preceded by east or northeast winds or (middle-west) by southern winds, and followed, after the passage of the storm center, by northwest or west winds; while storms of northwestern origin are preceded by south or southwest, and followed by west and northwest, winds. These facts show that offshore winds from the eastern and southern shores of Lake Superior are the general law for winds preceding most storms; and that after the passage of the storm center all appear to be followed by west or northwest winds. These offshore winds are likely to be onshore winds for Isle Royale. The proximity of the north shore, the frequency and magnitude of this wind phenomena, clearly suggests that these factors may largely account for the Canadian affinities of the majority of the Isle Royale biota. But we shall see later that there are other factors to reinforce this same tendency. It may seem unnecessary to enter these details, but it should be remembered that the conditions under which an organism may reach the island is an important factor in its survival, a relation of special importance in the migration of birds. That the majority of these storms occur in the fall and winter, at a period of relative inactivity on the part of the Isle Royale biota, is yet a condition which would be favorable for the transportation of some small hibernating invertebrates. The life histories of these storms, especially the conditions of their termination, may be expected to have an important bearing upon the survival of the drift biota.

There is still another important phase of this subject, and that is the influence which these storms have upon the life of the shore and beaches. The fauna of the exposed shore of Isle Royale is very scanty and much inferior to that of the harbors, so that, generally speaking, up to a certain point the more protected the coast the more diversified the fauna. This was very clearly shown by the molluscan life upon the shore. These storms have a powerful scouring action with the sand, gravel and shingle on the exposed coasts, so that a rock surface or one with blocks too large for disturbance by the waves is much more favorable to life.

The relation of waves to lake currents presents a significant phase closely related not only to the occurrence and distribution of life along the beach, but also to the problem of lake drift and its biological importance. A breaking wave tends to carry forward floating objects so that when such objects are carried along by the currents and once come within the range of influence of the breaking waves of shallow water, they tend to move with these waves into the shallow water and thus shoreward and are cast upon the beach in harbors, bays or about islands (Harrington, '95, p. VI.).

e. *The Surface Currents of Lake Superior.* Mention has previously been made of the fact that in addition to the offshore winds from Canada, which accompany certain severe storms, there are other influences which have a similar effect upon drift—the lake currents. These are, in part, an expression of the same climatic trend and their direction is a resultant determined by the influence of the prevailing westerly

winds, the rotation of the earth, the form and contour of the basin, and the position of the outlet. A detailed investigation of these currents was made by Harrington and Conger (Harrington, '95) who paid particular attention to the currents about Isle Royale. As these investigations were made during the season of navigation, they are of particular interest from the standpoint of the biota, because it is during this same period that we must in general expect the most advantageous dispersal of plants and animals to take place.

The simplest of these factors influencing currents are: the general movement toward the outlet of a lake, the prevailing westerly winds, the deflection to the right (or southward) of the current on account of the rotation of the earth. But the general form of the lake and its shore line, the contour of the bottom and the location of islands, introduce important complexities into the problem. As may be seen in *Fig. 53* Lake Superior well illustrates the influences of all these conditions. The small size of the outlet does not allow the escape of this vast current, so that there is a return along the north shore, where islands are encountered which produce eddies; and in their shallow water and along their coasts breakers are encountered which tend to carry shoreward and lodge drift.

When the return swirl reaches Isle Royale the problem becomes complex and is of such importance that these currents were made the subject of a special investigation by Harrington and Conger. In their study of the lake currents, bottles containing instructions were sent adrift and the finder was requested to communicate their recovery to the Weather Bureau. In this manner, supplemented by other sources of information, these currents were determined. The results of the investigations about Isle Royale are as follows:

"Not a single bottle has been recovered on the northwest coast of Lake Superior. This is not due to no bottles having been floated in that vicinity, as during the season of 1893 alone Mr. Conger floated 250 bottles between Duluth, Minn., and Thunder Bay, Ont.

"This fact was deemed of such importance that the Chief of the Bureau, accompanied by the inspector in charge of the Lake Marine Service, made a special trip from Duluth, Minn., along the northwest coast around Isle Royale to Port Arthur, Ont. Careful note was made of the entire coast, all beaches examined, and observations of water temperature made to assist in solving the direction of the current flow in this region. At French River, observations were made with special current floats, and it was discovered that the main current was to the northeast from 1 to 2 miles from shore. Inside this line was found a current flowing to the westward. This shore current evidently begins farther to the east, and continues to the west end of the lake, and is positive at or near Duluth, as is confirmed by investigation of the officials of the city of Duluth, however, narrow and does not extend far into the lake.

"Around Isle Royale there was found abundant evidence that the current flows to the west along the north shore of this island. Observations of water temperature at this point are very interesting and indicate a deep stream flowing from the eastward. There appears but little difference in the temperature of the water at the surface and at the

depth of 100 feet. In other localities to the southward there is a marked difference between the surface and deep water temperatures.

"In confirmation of this current there may be mentioned the following special drifts, the numbers referring to those on the chart*: (7) Drift of the yacht Albatross in summer, during a dead calm; papers thrown overboard remained alongside of the yatch for several hours; the drift was strong and uniform to the west. (8) Track of driftwood floated by party from the boat in a calm off McCargoes Cove, Isle Royale. (9) Drift of wreckage from the Silver Islet crib and pier which was washed away in a northeast storm. (10) Record of ice floes in calm weather during winter of 1891; reported to have drifted from the northeast to southwest at a rate of 3 miles an hour. (11) Drift of party in sailboat while becalmed on July 31, 1894. (12) Steamer Cumberland, which went to pieces on Rock of Ages, in 1877, whose wreckage was distributed along the entire south shore of Isle Royale. (13) Drift of a champagne bottle floated by Mr. W. H. Arnold, Port Arthur, Ont., on October 8, 1893; and (14) the drift of a fish barrel floated by J. H. Malone, keeper Menagerie Island Light, about August 27, 1885, and picked up twenty-six days later. The wind during this period was mostly from the south shore.

"The confirmations indicate that the current between Isle Royale and the north shore sweeps to the west and southwest after passing the island and recurving rejoins the main easterly current to the south and west; the drift of the wreckage from the Silver Islet pier indicates that it recurves at some point to the southwest of Grand Marais, Minn.

"Special attention is called to the current between Isle Royale and the north shore. The great depths, the conformation of the bottom, and the water temperatures in this locality indicate that there is a steady and fairly strong current sweeping from the east through the narrow pathway to the west, flowing to the southwest after passing the west end of the island, and rejoining the main easterly current as mentioned above. This narrow and relatively rapid stream, like the one between the Manitou Islands and the Michigan mainland in Lake Michigan is probably the most persistent and regular to be found in this lake. * * * *

"1. Section 79.—Floated by Capt. H. O. Jackson, steamer L. Shickaluna on June 23, 1893, at 6:45 p. m., in northwest corner. Found by Charles Lesage, Lake Linden, Mich., at entrance of McCargoes Cove, Isle Royale, on October 20, 1893, on the beach."

It is thus seen that drift from the north shore of Lake Superior tends to be strained from the lake currents by the various harbors of Isle Royale. It also suggests that north shore life might also reach Keweenaw Peninsula, but so far as known this has not been recognized. Drift was observed in Tonkin Bay which had evidently come from a distance and dead birds reported by Peet, as drifting into Washington Harbor, probably came in part from the north shore current. The long duration of these currents since the Ice Age seems very probable, and undoubtedly they have had an important bearing upon the geographic origin of the Isle Royale biota, so that they cannot receive too much emphasis.

A few words may be added concerning the probable history of the

* Not reproduced on the map or figure.

lake currents. Since the location of outlets, prevailing winds, topography of the basin and rotation of the earth all influence lake currents, it is evident that any important change in these conditions will cause a modification in the currents. By means of these criteria then we may infer what currents are likely to have existed under certain conditions. Some of these conditions have had a very permanent value in the Superior basin, because the general form of the southern shore (except Keweenaw Peninsula), the earth's rotational deflection to the right, and the prevailing westerly winds, made relatively definite conditions. Thus the early Glacial lakes in this basin, which had southwestern outlets, must have had different currents, perhaps more or less against the prevailing westerly winds, and the absence of large islands would be favorable to uniformity. Later at the Algonquin stage, *Fig. 52*, there must have been a very complicated system of lake currents, perhaps a rough outline of those of the present Great Lakes, at least in the deflection toward the right shores on account of the rotation of the earth, and to the eastward on account of the prevailing westerly winds and the eastern outlets. The broad connection between the Superior and the Huron basins perhaps also favored a north shore return whirl, while at the Nipissing stage, *Fig. 54*, in the Superior basin the currents were in general quite similar to those of the present lake, but more simplified in detail by the greater depth of the lake.

If such general relations as these obtained, it will be seen that the north shore return whirl may have been of considerable duration, and that the opportunity for these currents to carry life from the south shore must have been constantly less favorable than the chances for them to effect transportation from the north shore of the Superior basin. In this basin then it seems that the currents were first relatively simple, became quite complex at the Algonquin stage and were simplified at the Nipissing stage. A detailed study of the beach lines such as those of the Nipissing, might add much positive information as to these ancient lake currents and their biological relations.

f. *The Origin of the Habitats.* Isle Royale is about 45 miles in length, has an average width of about seven or eight miles and an area of about 210 square miles. The shallow soil, rock ridges, forested swamps, lakes, small streams, rocky coast, and harbors provide a variety of conditions and furnish play for such a variety of processes that many diverse habitats are produced. Generally speaking, the island is covered with a stunted coniferous forest growth. Attention has already been called to some of the conditions and processes which have produced the major environmental regions and the general topography of the surface. If Isle Royale had high mountains and greater extent, very different habitats would be expected.

As we have seen, the entire surface of the island has been beach, and previous to that it had been a reef in the lake, so that the beach represents the original land habitat upon the island. Generally speaking this habitat has migrated from the crest of the Greenstone Range downward for about 550 feet to the present lake level. With this progressive downward movement, there has been an increasing area exposed to subaerial processes of erosion. The origin of the harbors has been a part of the beach problem, but that of the protected beach,

these with the falling of the lake have migrated outward, as is suggested by the courses of the main streams occupying the rock valleys.

The very immature condition of the drainage shows that during the present post-Glacial cycle only comparatively slight changes have modified the relief from the condition in pre-Glacial times; it is thus largely an inherited topography, hence the consequent drainage. It should perhaps be added, however, that the date of the faulting is not definitely known; it may be very ancient, but the weight of the ice sheet may have had considerable influence. It thus seems probable that with the decline of the lake level there has been an increase and downward elongation of the stream environments, and that their course has been determined largely by the pre-Glacial topography, supplemented, of course, by the southward tilting of the land. The lake basins have had an origin similar to that of the streams and have tended toward extinction by tilting, inwash, organic debris and to a limited extent by the downcutting of outlets. On account of the relatively small amount of erosion by the ice sheet it is probable that the shallow swamps and the smaller streams were influenced more by the ice than those features related to the greater relief of the surface; even moderate tilting would considerably influence such an environment, because within the major valleys the divides are generally low.

The origin of certain land habitats only remains to be considered. These have undergone a complex succession of changes. The resistent lava of the Greenstone had been the least reduced by erosion so was the first to emerge from the lake level. This was first a beach, and as the water fell from its crest the upper beach migrated to lower levels and the land habitat continued to increase in area. The beach line itself expanded laterally, if not in width, as the area of the island increased. When once the exposed rocks were beyond the reach of the waves, weathering and erosive processes were initiated which tended to produce a residual soil. Plant remains from lichens were perhaps the first humus formers, and it is probable that it was not until the period of Lake Algonquin that the lake drift which was washed ashore became a source of such material; but winds, birds, lake currents and the waves may all have contributed pioneers of the higher plants. The harbors at the northeastern end of the island would tend to strain out the drift from the southwestward flowing current and the returning one along the southeastern coast of the island would tend to lodge drift in Washington Harbor and the Siskowit Bay region.

As the water continued to fall to lower levels, the land biota followed down the slopes behind the receding beach. By the Nipissing stage, the vegetation and many animals were probably well established and had begun to actively encroach upon the swamps and lakes and thus tended to increase the land habitat. With the tilting that followed the formation of the Nipissing beach, a readjustment must have taken place between the land and water habitats, but to what degree their relative areas were influenced is not known. During the initial elevation ponding would be expected at the northeastern end of the island, but with a greater elevation this same area would be well drained, as the divides in the valleys are low and the transverse drainage near the central part of

the island would tend to prevent extensive ponding, combined with the fact that the valleys extended in the same general direction as the uplift and not across it. It therefore appears that many processes have tended to increase the land habitats at the expense of the aquatic, such as the falling of the lake level, the encroachment of organic remains on the depressions, the perfecting of drainage lines and the tilting of the surface.

With the advent of the forest a habitat differentiation developed in contrast with the natural openings. These openings were originally due to the lack of soil, as on the ridges, wave action, as on the beach, or an excess of water as in the depressions. With the accumulation of soil, the downward migration of the waves, and the filling up or draining of the depressions, the range of the forest has been extending, and is tending to completely cover the surface.

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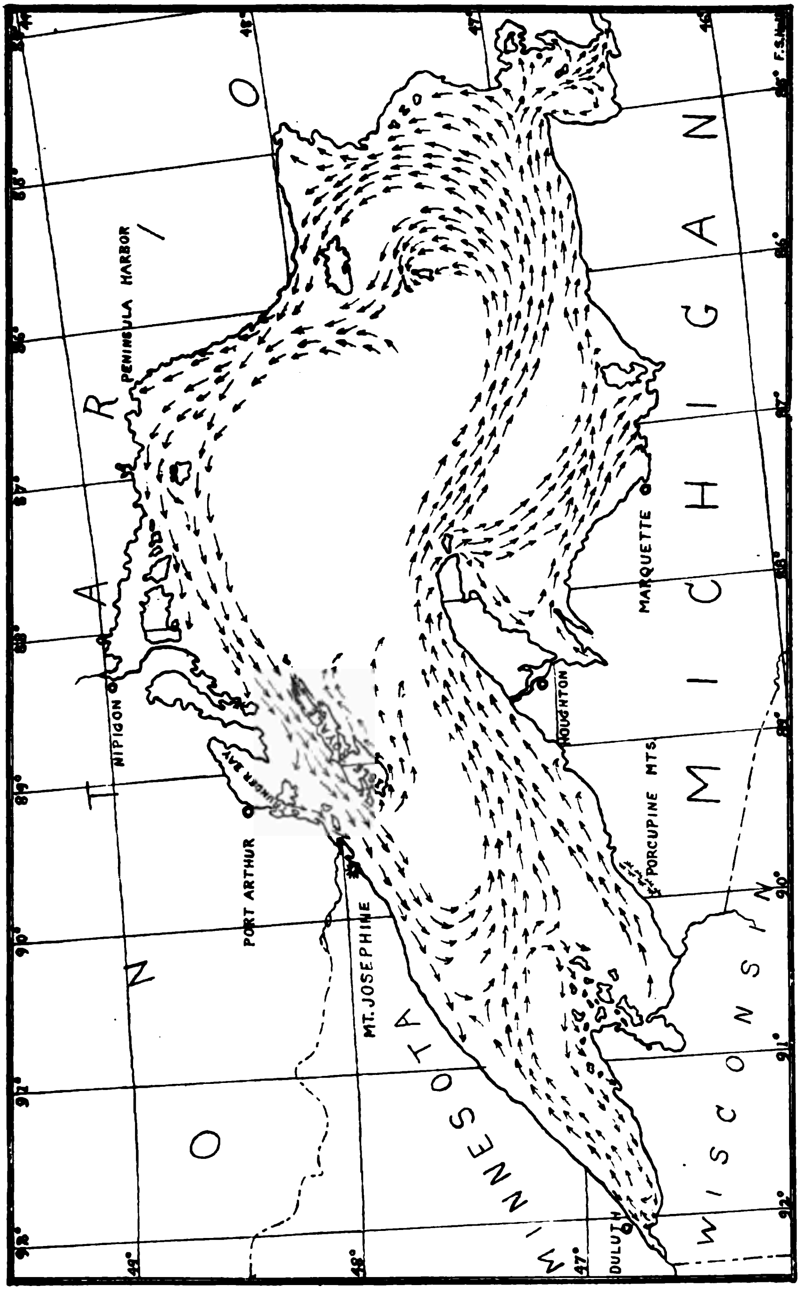


Fig. 55. Surface currents of Lake Superior. To show their possible influence on the origin of the biota. (Drawn by Hall, after Harrington.)

FIG. 56. "THE WENDIGO ROAD," FROM THE CLEARING AT THE CLUB-HOUSE TO WENDIGO, WASHINGTON HARBOR.

FIG. 57. LONG ISLAND (V. 10), SISKOWIT BAY, LOOKING TOWARD ISLE ROYALE LIGHT-HOUSE.

FIG. 58. GULL ROOKERY ON LONG ISLAND (V, 10), SHOWING HIDING INSTINCT OF GULL.

FIG. 59. GULL ROOKERY ON LONG ISLAND (V. 10).

FIG. 60. EAGLE NEST AT TOBIN HARBOR (IV, 8).

THE ECOLOGICAL RELATIONS OF THE INVERTEBRATE FAUNA OF ISLE ROYALE, MICHIGAN.

BY DR. HENRY ALLAN GLEASON.

I. *Introduction.*

The most recently emerged portions of Isle Royale are the rock and gravel beaches which together constitute virtually the entire shore of the island. Animal life is found upon them almost to the edge of the water, and well within the limits of wave action. The physiographic succession in the island is such that the areas originally occupied by beach pass through a series of changes in the physical factors, a series which is accompanied, sometimes hastened, sometimes retarded, by corresponding vegetational successions, and which culminates in the final or climax plant association of balsam and spruce forest. The detail of this physiographic and vegetational succession is by no means uniform; it may proceed along either of two well-marked lines, depending on the immediate physical and biotic conditions, certain intermediate stages may be prolonged or omitted entirely, and various other deviations may occur. Nevertheless the final stage is always the same. Accompanying the changes in physiography and vegetation is a similar and dependent change in the fauna, so that there is a corresponding series of animal associations, beginning on the beaches and developing in the same direction, with the same deviations or omissions, to the final or climax association in the balsam-spruce forest.

The preceding general statement rests on the assumption that the areas now occupied by the climax biotic associations have developed from the beach associations through a series of stages intermediate in time corresponding to those associations which now stand intermediate in space between the two extremes. Or briefly, as some ecologists have expressed it, the lateral distribution in space recapitulates the vertical distribution in time. Such an assumption is evidently closely akin to the recapitulation theory of the evolutionists, and just as that so-called biogenetic law has been accredited with more than its true value, so has this ecological dictum possibly much less importance than has been usually supposed. The weakness lies in too little consideration of the time element. It is certain that the higher land in Isle Royale has been submerged. This is shown by the old beach marks now many feet above the present level of the lake. Consequently by the gradual emergence all of the island has passed through a beach stage. But it is unwarranted to conclude from this that the faunal or floral associations of the former beach were similar to those of the present, or that in the intermediate stages the biota resembled that which now occupies the area between the ancient beach and the present shore. While it is likewise certain that with a continued subsidence of the lake level the present beaches will eventually be left far above the water, it must not therefore be assumed that their biota will show the same successions or reach the same climax as those of the past. Changes in the tempera-

ture or rainfall may certainly keep pace with the changes in lake level, or even be caused by it, and in either case they would exert a profound influence on the biota. Migration of species is still taking place among both plants and animals, and may introduce new or even dominating species among the present forms. The so-called equatorial pressure of southern species is fully as strong now as it was directly after the close of the glacial epoch. Lastly, and most important of all, the influence of the biota itself is always to be reckoned with. Both plants and animals are continually becoming more plastic, adapting themselves to new conditions, and extending their habitats into new associations. They push forward more rapidly than the changes in physiography, sometimes hastening and sometimes retarding physiographical action, and at all times greatly influencing the subsequent successions.

A biotic association may develop into another by a mere re-arrangement of the interrelations, numerical or otherwise, of the component species, without the necessary loss of some or addition of others. But such cases are rare, and the Isle Royale observations show that no two associations have exactly the same species, and that with each progression there has been an addition of certain forms which become the most characteristic types. The first bit of beach formed was occupied by an association possibly not unlike that of the present beaches. All the species must evidently have immigrated from beyond the island. When the soil deposits on the beach were sufficient to support a second association its species were derived partly from the beach itself and partly from new immigrants. The further development of biotic associations on the beach was then possible not only from immigrants, but also from the two associations already present. Similarly at the present time each association on the island is constantly being invaded by species from all the others, and many of them are actually able to establish themselves. This tends toward a homogeneity in the biota hardly in full accordance with the recapitulation idea. Indeed, it is very probable that independently of all physiographic agencies the whole surface of the island would eventually be occupied by the balsam-spruce forest and its attendant faunal association.

In many cases it is virtually certain that the lateral succession does faithfully repeat the vertical, and the zonation of plants around a pond may be taken as an example, but the filling of a pond is only a single step in the genetic development of the biota of an island.

With this preliminary note of warning, the truth of this recapitulation theory will be assumed for the island, and the discussion of the insect and molluscan fauna will follow the genetic lines indicated in the first paragraph.

The relationship of the various physiographic types on the island to each other may conveniently be expressed by a diagram (see end of paper), indicating the direction of the devolpment by arrows. It must be remembered that practically any one of the intermediate stages may be omitted.

II. The Lake.

The lake (Superior) must obviously be regarded as the first stage in the genetic development of the faunal associations. Broadly speaking, the lake fauna is divisible into two main groups. The first is pelagic in

character and includes those species whose distribution is entirely independent of the shore, for example, most of the species of fish. The second group is littoral; the species occur along the shore in comparatively shallow water, and are to a greater or less extent dependent upon the land in its relation to the character and slope of the bottom and to the motion of the water. Members of the latter group only are considered here.

The two dynamic factors just mentioned are the most important ones that influence the biota of the lake. There are no currents of sufficient rapidity to affect the animal life. The direction of the wind, whether off-shore or on-shore, may respectively lower or raise the level a few centimeters, especially when the wind blows lengthwise of the long narrow inlets, such as Conglomerate Bay (*Fig. 11*). Some fixed or slow-moving species may accordingly be alternately submerged and exposed, while motile forms can at once adjust themselves to any change of level. Of far greater importance is the motion of the water caused by wave action. It is only on rare occasions that the lake is quiet. Gentle waves come in nearly all the time, and after storms become of great violence. Wave action is of itself sufficient to inhibit the growth of shells along the exposed shores, where they might easily be torn loose and crushed against the rocks. Such forms are consequently restricted to the shores of the smaller bays or to the lee side of islands.

Wave action is of importance further in determining the character of the bottom. Where the shore is exposed directly to the lake it is usually of massive rock, all the fragments having been washed down to deep water. In small shallow coves, where the waves break always in one direction there is usually a sloping beach of gravel extending across the end perpendicular to the direction of the waves. Every breaker sorts over this gravel so that it is nearly impossible for a fauna to develop. In larger coves or bays, where the violence of the wave action is reduced by distance, the gravel is finer or even a beach of sand may rarely be formed. Along the steep or cliff-like sides of these coves the bottom is frequently covered with angular rock fragments too large to be moved by the water. These are frequently inhabited by shells. In general the development of a free littoral fauna demands quiet water where the animals will not be dashed on the rocks or stranded on the shore, and for attached species there is required either quiet water or a firm bottom which will not be dislodged by the waves. A more detailed discussion of this as affecting the distribution of shells will be given later.

In the larger inland lakes, of which Siskowit Lake, the only one of the class studied, may be taken as an example, essentially the same conditions obtain as on Lake Superior itself. The difference in temperature and content of the water seems to be of minor importance. The waves in the larger lake can naturally reach a larger size, and their influence is felt far into the bays. Thus at the head of Rock Harbor, about six kilometers from the lake proper, the distribution of shells and the almost total absence of free forms indicate that even there wave action is of importance. In Siskowit Lake, although larger than Rock Harbor the force of the waves is so reduced by every headland or island that on the quiet water in their shelter a rich fauna of such free forms as

water-striders and whirligig beetles is found on the surface, while numerous mussel shells live on the silt or sand bottom. In Sumner Lake and others of limited area the motion of the water has no measurable effect on the biota, and they will therefore be treated under a separate heading.

The distribution of shells along the shore, particularly species of *Limnaea* and *Physa*, is of especial interest. Having relatively low motility they are correspondingly limited in their distribution and the factors governing it are more readily determined. These will perhaps be made clearer by concrete illustrations.

Tonkin Bay is a small inlet about half a kilometer long, opening to the east upon the lake, and with steep, approximately parallel sides. It is narrowed half way up by two beaches lying perpendicular to its length. By this the wave action on the upper part is reduced, but still may sometimes be sufficient to wash heavy drift-wood upon the beach. In the outer half the wave action is but slightly less than on the lake itself, and no shells are found. In the inner or upper half *Limnaea stagnalis* L. (Nos. 50, 54, 57), *Limnaea emarginata* Say (Nos. 50, 57), and *Physa sayii* (Tap.) (Nos. 50, 57), live along both sides where the bottom is rock, but not across the ends. They live only on a rock substratum, which may be either horizontal or vertical, and in water up to 45 cm. in depth. The larger species, *Limnaea stagnalis*, is more abundant in the deeper water, and only the smaller species live at a depth less than 15 cm. They then prefer the vertical walls to the horizontal or flat bottom.

Conglomerate Bay is a rocky inlet (*Fig. 11*) similar to the one just described and about 1.6 km. long. Being wider at its mouth than Tonkin Bay the force of the wave action is felt farther up the bay. Near the end the waves have little effect, as is evidenced by a sandy beach (*Fig. 4*), almost without driftwood. At the upper end of this bay along the north side *Limnaea emarginata* Say (Nos. 118, 125) and *Physa sayii* Tap. (Nos. 118, 125) are found in water 15—45 cm. deep, in the deeper water on the tops of flat rocks, in the shallower water, also on the vertical sides and in small crevices. They never occur on the sand or gravel deposited around the rocks, as is frequently the case near the sand beach at the upper end of the bay. The distance to which they extend from shore is greatest opposite the concavities of the shore line and least opposite the small rocky headlands. Their distribution in both Tonkin Bay and Conglomerate Bay seems to be regulated mostly by the wave action, since they seek the most protected places, avoid the shallow water where the waves would strike them most, and do not live on loose or small rocks, gravel, or sand, which would easily be dislodged. The fact that the smaller shells are found at the least depth, while the larger *Limnaea emarginata* inhabits the deeper water, would indicate that the small size of the former renders them less easily dislodged by the waves. Again their greater abundance on the north side suggests the possibility of a light relation.

Siskowit Lake, with its rocky shores and large area, offers essentially the same condition as Lake Superior itself, and the shells have the same general distribution. Along the very gently sloping rocky shore near the outlet *Limnaea stagnalis* occurs in abundance, always at a depth

of 10-40 cm. Along the south side of a large island near the south shore, where they are sheltered from waves in every direction, the same species is abundant. They live on rocks in the full sun in water 10—45 cm. deep, with the optimum depth at 20—25 cm. They may occur on the tops or sides of rocks, but never on the sand between them. Associated with the *Limnaea*, but much less abundant, are *Planorbis bicarinatus royalensis* Walker (No. 210), *P. campanulatus* Say (Nos. 210, 211), *Lampsilis luteolus* (Lam.) (Nos. 210, 211), *Anodonta marginata* Say (No. 210), and *Anodonta grandis footiana* Lea (Nos. 210, 211).

Opportunity was given to observe the behavior of *Limnaea stagnalis* (No. 217) in waves of some size near a small circular island half a kilometer out in the lake. The bottom was gently sloping, and either of solid rock or of large rounded fragments. There were no overhanging trees, so the shells were found in uniform abundance in the usual depth of water on all sides of the island. At the time the island was visited a strong wind was blowing, and the waves were probably nearly as high as they ever become on Siskowit Lake. One or two shells were seen which had been washed loose, and of course would be unable to reattach themselves until the waves abated. It would be expected that in such cases the shells might be crushed or broken or the animal killed. That such may happen was evidenced by finding a few live shells which had been cracked and then healed, leaving an irregular surface. Their occurrence here and elsewhere only upon rocks of considerable size shows that they require a firm substratum, and where the rocks are free from any coating of slime they can certainly endure higher waves. Around the island under discussion the rocks were washed perfectly clean.

The beach in front of the camp at Siskowit Bay (*Fig. 29*) was inhabited by large numbers of (No. 200) *Physa sayii* Tapp., *Physa* sp., *Limnaea stagnalis* L., and *Limnaea emarginata* Say, so that more detailed observations of them could be made, and a few experiments carried out to show their sensitiveness to the depth, or bathytropism, as it has been termed. The beach here is of rock with a gentle slope of about one in five, corresponding to the dip, except where blocks have worn off, leaving low vertical walls. The wave action here is very light, its force being cut off by a series of islands lying between the beach and the main body of Siskowit Bay. This was well shown by the conditions on August 2, when there was scarcely a ripple inside the islands, although the bay outside was covered with whitecaps. The beach is covered with a thin coat of slime formed mostly of excrement from the snails.

On such a beach snails may live close to the edge of the water, but the larger *Limnaeas* still occupy their usual depth of 1.5 to 4.5 decimeters. About 10 A. M., on August 3, all the shells to a depth of about 1 decimeter were gathered from a strip of the beach about 10 meters long. They were comprised in the following species: (No. 200) *Limnaea stagnalis L.*, *Limnaea emarginata* Say, *Physa sayii* Tapp., and *Physa* sp. The smaller *Physas* were especially abundant and about 200 of them were taken. Four hours later, at 2 P. M., 60 shells, all of the smaller species, had migrated upon the same strip. The only evidence concerning the way that they came is that one shell of *Limnaea stagnalis* was seen to drift up over a low wall into the shallow zone. This method could

hardly account for 60 of the smaller ones, however, appearing in so short a space of time. It may be taken as indicating a general and continued migration in all directions within their bathytropic limits.

It was noticeable that the large *Limnaea emarginata* and *Limnaea stagnalis*, aside from the one specimen mentioned above, live at an average depth of 3 dm. and never deeper than 4.5 or 5 dm. To test their bathytropism six of them were picked out of the deeper water by hand and held in contact with the bottom in the shallow zone until they extended their feet and attached themselves. At this time the water was very quiet, moving just enough to cause a faint sound on the beach. But the size of the shell of the two *Limnaeas* is so large that they offer considerable surface to the water and are consequently easily washed loose. Two of the six swung a little from side to side and were then washed off and carried by the undertow into water 3 dm. deep, where they again attached themselves. A third, without being shaken by the waves, clung to the rock for some time, then suddenly let go its hold and drifted over a low ledge into the deeper water. Two others immediately started to crawl down the slope, and one in about fifteen minutes, the other in about half an hour, had crawled over the ledge into water 3 dm. deep, where they both remained stationary. The sixth remained attached, and in three hours had crawled 2 dm. parallel to the shore, keeping at the same depth. The next morning, twelve hours later, it had disappeared, and of course could not be recognized in the deeper water.

On August 4 two shells of *Limnaea* appeared in the shallow zone, but it is not known whether they drifted or crawled up. They were there at least three hours. After they were last observed a fresh breeze sprang up from the east and the slight wave action caused by it probably washed them down.

The level of the lake varies somewhat with the direction and intensity of the wind, so that in front of the camp a strip of beach up to 5 dm. in width may or may not be covered with water. The smaller shells, *Physa sayii* Tapp. and *Physa* sp., live in this zone in spite of the fact that they are sometimes out of water. So far as observed they are never exposed for any considerable length of time, so that they do not become dry. Then again the weathering of the rock has left bowl-shaped hollows a centimeter or so across and about the same depth, and the snails usually get into them.

To summarize, the known facts bearing on the distribution of these four species are as follows:

1. Their lower limit is 4.5 to 5 dm. depth of water, governed possibly by the water-pressure or the food supply.

2. The upper limit is for *Limnaea stagnalis* and *Limnaea emarginata* 1.5 dm. of water, for *Physa sayii* and *Physa* sp. the shore-line. The cleaner the rock and the less the wave action the shallower the water which they may inhabit.

3. Their horizontal distribution is controlled by (a) full exposure to the sun; (b) a rock bottom; (c) a certain minimum of wave action.

But two species of insects were collected which should properly be considered here, caddice flies and stone flies. The larva cases of the caddice flies were collected only in the outlet of a small stream emptying into Rock Harbor, in 1—1.5 m. of water (No. 163 or

164), but the imagos were common all along the shore of the lake, especially on the gravel beaches. One (No. 192) was taken on the boat about 2 km. off the south shore of the island. Stone flies were also frequently collected along the beaches, where they came up to breed. They were most numerous, however, on steep or even vertical cliffs with southern exposure (Nos. 24, 80). Near the entrance to Conglomerate Bay (*Fig. 2*) they were seen collected in such a place by thousands. The water there was at least 4 m. deep.

A few hair-worms, *Gordius aquaticus* (L.) (No. 207), were collected in 2 to 3 dm. of water on the rock beach (*Fig. 30*) in front of the camp on Siskowit Bay.

The various mussels collected in Siskowit Lake and elsewhere, even though sometimes associated with *Limnaea stagnalis,* belong rather to the associations of the smaller inland lakes.

III. The Inland Lake.

The smaller lakes are mainly surrounded by tamarack swamps, with the vegetation showing the characteristic zones, certain ones of which, as the rushes, water-lilies and pond weeds, live in the lake itself. The bottom is covered with peaty mud or with slime, and the wave action is never severe enough to interfere with the growth of either fauna or flora. In many of the smaller lakes, in fact, the water lily zone is so wide and the open water so restricted that there is practically no wave action at all (*Fig. 46*). Accordingly both fauna and flora are richly developed both in species and individuals. The fauna may be roughly classified into several groups according to their habitat in order to facilitate description. The interrelations of the different species are complex in the extreme, and of course could not be properly worked out in such a short time as the lakes were under observation.

a. *The Fauna of the Bottom.* In Sumner Lake (III, 5) (*Figs. 18-22* and in sheltered places in Siskowit Lake several species of shells live on the bottom in sand or mud and at a depth of from 3 dm. to 1 or 2 m. *Planorbis trivolvis* Say (No. 135) lives in the shallower water, preferably in mud. It is nowhere abundant, but was collected in both lakes. One specimen only was found in Sumner Lake in a little pool with mud bottom. Shells were commoner on the shoreward side of an island in Siskowit Lake, on a bottom composed of sand and mud. They were well buried under the sand and the majority of the shells were dead.

Mussel shells, especially *Anodonta marginata* Say and *Anodonta grandis* Lea, were common in all the smaller lakes and at the upper end of Rock Harbor. They were most abundant in the deeper water with a sand bottom, particularly where there was comparatively little vegetation. In certain sheltered bays at the upper end of Siskowit Lake they were especially numerous. Muskrats carry them to the shore to eat, and leave the empty shells in heaps, which were conspicuous sights along most of the lake shores. In Sumner Lake live shells were very scarce, but the piles of dead ones on the bank testified to their former abundance.

At the upper end of Rock Harbor some small shells, *Planorbis bicarinatus* Say (89), *Planorbis exacutus* say (89), *Planorbis parvus* Say (89, 163, 164), *Valvata tricarinata* Say (89, 163), *Valvata sincera ny-*

landeri Dall (89, 163, 164), *Amnicola lustrica* Pils, (89, 163, 164), and *Pisidium* sp. (163, 164), and Amphipods were dredged from a depth of 1.5 to 2 meters near the mouth of a small stream (*Fig. 22*) where the bottom was thickly covered with small twigs and other coarse vegetable debris. From the same place the caddice fly larvae were obtained, as mentioned previously. The same fauna was collected in the stream itself, but only near the mouth, where the water was deep, the current slow, and the conditions in general much like those of a lake. May flies probably breed in similar places. No larvae were seen, but a few imagos were collected (No. 178).

The fauna of the bottom shows a connection through the presence of *Pisidium* sp. in the last case with that of the small streams in the tamarack swamps and with that of the brooks, like the outlet of Siskowit Lake. The accumulation of vegetable debris and the more restricted amount of water are both approaches toward the conditions in the former places. In Siskowit Lake, where *Planorbis campanulatus, Planorbis bicarinatus royalensis* and *Anodonta grandis footiana* were associated with *Limnaea stagnalis,* another transition was shown between the faunas of the inland lakes and the larger lakes as typified by Lake Superior itself.

b. *The Free Fauna of the Water.* No species were observed except fishes and leeches. The latter were abundant in Sumner Lake, especially among the water lilies and in the shallow water along the shore.

c. *The Fauna of the Surface.* Hardly belonging properly to this group were the small shells, *Limnaea catascopium* Say (220), *Physa* sp. (220, 221), *Valvata sincera nylanderi* Dall (220), and *Amnicola limosa* Say (220), found abundantly on the under side of water lily leaves. Their distribution is directly controlled by that of the water lilies, that is, near the shore, and in the larger lakes only in the sheltered bays. Probably a third of the leaves had one or sometimes two shells attached to them. Water striders, *Gerris remigis* Say (No. 96), were abundant, usually near shore in the water lily zone, but occasionally out in the open water. Whirligig beetles, *Gyrinus minutus* Fabr. (No. 219) were also common, but not abundant on the smaller lakes. In the sheltered bays of Siskowit Lake they collected in immense swarms, keeping mostly near the shore among the water lilies and under overhanging brush. *Donacia proxima* (Nos. 171, 184) and *Donacia cincticornis* (Nos. 171, 175) were abundant on Sumner Lake, resting on the water lily leaves. When alarmed they would fly a short distance close to the water, making a little trail behind them, and alight on another leaf.

d. *The Free Aerial Fauna.* Dragonflies of several species are abundant along all of the lakes. They usually keep close inshore or over the water lilies, and fly regularly in patrols around the lake, searching all the time for insects but keeping up a uniform rate of speed. *Aeschna* sp. was probably the most abundant, and associated with it were *Enallagma hageni* Walsh and *Leucorhinia proxima* Anth. The butterfly *Argynnis atlantis* Edw. also occurs (No. 169).

The inland lakes may be regarded as small detached portions of the main lake, cut off from it by the lowering of the level of the latter. Since they are composed of stagnant water with little or no wave action, where organic material may accumulate in quantity, they support a

different fauna and their genetic development is along a different line, culminating however in the climax type or balsam-spruce forest. The only intervening stage is the tamarack swamp.

IV. The Tamarack and Arbor Vitae Swamps.

Nearly every inland lake in the Isle Royale region is wholly or partly surrounded by tamarack swamps, (*Figs. 14, 19, 22, 41, 47, 48*). It is not necessary to discuss the general structure of the vegetation, since that is described elsewhere in this report, but it may be indicated here that the ground cover is a spongy mass of sphagnum covered with a dense growth of ericaceous shrubs, such as Cassandra and Ledum, and that the trees are almost entirely tamarack and black spruce. The forest cover is open enough to allow ample illumination. Tamarack swamps may be found of all ages, from those developing at the edge of a lake to those which have completely covered the lake and are now dying as an association. Their surface is generally level, the older parts being successively somewhat higher as they are built up by the accumulations of peat.

When the level is nearly that of the lake the beds of sphagnum are interspersed by little streams or pools of water, some of them being merely extensions of the lake itself, or some of them serving as inlet or outlet. The smaller ones have no bottom except the sphagnum itself, while the larger have a loose incoherent bottom of slime. In the larger of these streams are found small bivalve shells, *Pisidium* sp., embedded in the slime at the bottom (No. 230; V-5), and other material; and the beetles *Haliplus ruficollis* DeG., *Hydroporus tristis* Payk, and *Agabus congener* Payk. (No. 230, V-5). In the smaller ones, which are frequently only a decimeter or two wide and half as deep, there is no difference in the vegetation except for a little Utricularia in the bottom. Animal life is there very scarce (No. 237, V-5), but included *Pisidium* sp.

As the swamps become older the water is limited to small shallow pools, seldom more than one decimeter deep or three or four decimeters wide. Their bottoms are covered with dead leaves and sphagnum, and they are usually densely shaded by the forest growth above. In them are found small bivalves, *Pisidium affine* Sterki (77A, 79A), *P. subrotundum* Sterki (116, 181, 182, 237), *P. subrotundum* Prime (116, 237), and water beetles, *Haliplus ruficollis* Deg. (No. 116, I-4) and *Scutopterus hornii* Cr. (No. 181, 144). The latter is restricted, so far as observed, to this single habitat in the pools in tamarack and arbor vitae swamps. Dragonflies are the principal aerial insects, but are not abundant. A fly (No. 240, V-5) was taken on the flowers of *Solidago neglecta*.

In still drier swamps, where there is no longer any standing water, (*Fig. 14*). ants are a characteristic feature of the fauna. They build huge dome-shaped nests, 4 to 7 dm. high, composed within of sphagnum and other vegetable debris, and smoothly covered on the outside with leaves of Cassandra, doubtless to prevent drying. *Formica adamsii* Wheeler (No. 115, I-6) seems to be the only species concerned, and a nest from which the collection was made was photographed. No. 114, taken at the same time from a similar nest, has been identified

as *Formica dryas* Wheeler, suggesting a possible confusion of the numbers. No other insects were observed except the omnipresent black-flies and mosquitoes.

At the head of the numerous fjord-like inlets along the shore there is usually a swamp tract extending for some distance inland in the same direction as the inlet itself. The level is but little above the lake itself, but there is no permanent standing water or lakes as in the tamarack swamps. The standing water is limited to small scattered pools, seldom more than a meter across, and the forest cover is prevailingly of arbor vitae. The shade is exceedingly dense, and the ground is covered with tangles of underbrush and fallen logs. The fauna is accordingly reduced to a minimum, and the few forms collected were all dredged from the leaf-covered bottoms of the small pools, and included bivalve shells, *Pyramidula striatella* (Anth.), and *Pisidium subrotundum* Sterk. (No. 182), and water beetles, *Scutopterus hornii* Cr. (No. 182). The latter were very scarce.

Faunistically the arbor vitae swamp is very closely related to the later stages of the tamarack swamp, as a comparison of the species will show. At the ends and around the sides the swamp grades imperceptibly into the balsam-spruce forest.

In connection with the swamps must be mentioned the fauna of the small rapidly flowing streams leading out of the inland lakes. The bottom is usually rock or gravel, and the swift current prevents the accumulation of organic debris. In Benson Brook on the north side of Rock Harbor in still, deeply shaded places were dredged up (No. 149) *Pallifera dorsalis* (Binn.), *Pyramidula alternata* (Say), *Pyramidula striatella* (Anth.), *Zonitoides exiguus* (Stimp.) and *Physa* sp. In the outlet from Siskowit Lake, in small pools 5-15 cm. deep with a bottom of slime covered with loose pebbles, were collected several shells (No. 238), *Physa* sp., *Pisidium medianum* Sterki, *P. subrotundum* Sterki, and *Musculium securis* (Prime). The current where these were collected was very slow. In the more swiftly flowing water nothing could be found.

Owing to the peculiar geological structure of the island the swamps have a generally oblong form with approximately parallel sides. Along the sides the swamps grade imperceptibly into the balsam-spruce forest (*Fig. 43*), and on the ends as well, though there the transition is more gradual and the facies are usually separated by an intermediate zone marked by dense thickets of alder.

V. *The Gravel and Sand Beaches.*

The gravel beaches are found in but certain places along the shore (*Fig. 1*), where the slope of the banks and the action of the waves permit the formation of the gravel deposits. Optimal conditions are found at the heads of the numerous inlets or coves; such as Conglomerate Bay (*Fig. 4*), and Tonkin Bay, already described, and many other similar places. They also occur, however, along the shore of the lake itself, where the wave action is at its minimum. Their distribution appears to be controlled principally by the slope of the bottom, since the gravel could not be piled up on slopes of too steep pitch, and they are almost

invariably in locations so bounded by rocks or shore that the waves strike them always in one direction. An instance of this was seen near the light-house. A small inlet about 5 m. in length and width opened towards an island. Waves struck it in two directions, both diagonally, but rebounding from the rocks continued into the inlet in one direction. At its back was a small but typical beach, the only one in the immediate vicinity and likewise the only spot where the waves always came in the same direction. As a consequence of this directive action the beaches always lie at right angles to the direction of wave action.

The gravel of which they are composed varies in size from fragments as large as one's fist to mere sand, but the biota of the sand beaches is so different that it requires separate discussion. There is no vegetation, but the beaches are frequently strewn with dry drift wood in which several kinds of fruits, dead insects and shells may be found. The gravel is dry on top, but is always moist at a depth of one or two decimeters or even less. The broader beaches have full exposure to the sun, but the narrower are shaded, and all are bounded at the rear by a narrow but dense zone of alder.

The fauna of these beaches is limited in species, probably owing to the lack of food, although the number of individuals is relatively large.

Caddice flies are rather common running about over the finer gravel just above the reach of the waves, or sometimes taking short flights (No. 10). Stoneflies are associated with them; they crawl about actively over the wet gravel near the water's edge and do not attempt to fly. They are frequently struck by waves which merely wash them a little farther up the bank. A few species of ants are also common, running over and through the gravel (No. 38). They prey on dead caddice flies or even on live ones when they succeed in capturing them. The most characteristic group, however, consists of several species of spiders, which are found in great abundance on the coarser gravel in the sun (Nos. 16, 25, 38, 39, 60), *Lycosa pratensis* Emer., *Pardosa lapidicina* Emer., *Pardosa groenlandica* Thor., *Ebo latithorax* Keys. They run with great rapidity and at the least alarm crawl under the rocks, where it is almost impossible to find them. After the first alarm they usually show themselves in 10 to 15 seconds, but being frightened again, they crawl for some distance under the gravel and are lost permanently. Many of them carry egg cases, and if forced to drop them they spin a web which they follow back in a short time. These spiders are very numerous, probably 10 or 12 to every square metre over all the gravel beaches.

Other insects observed were, a small beetle (38) crawling over the sandiest part of the beach; two species of small beetles (39) crawling through the coarse sand and fine gravel at the water's edge; a click beetle, *Corymbites medianus* Germ. (41) crawling over sand in a shaded place near a rock cliff; a Scarabaeid, *Serica vespertina* Gill. (43); a beetle, *Macropogon rufipes* Horn (60). Some fish worms (40) were also found buried 3 dm. deep in moist coarse sand under the gravel beach in front of the light-house. They were above the level of the ground water. Butterflies and wasps, which were so abundant on the

sand beaches, were collected but once. The butterfly, *Pyrameis cardui* Linn. (39) flew out of the woods, rested a moment on the gravel, and then visited a dogwood flower. The single wasp (41), *Ammophila* sp., was seen flying low over a small area of sand near the water's edge on a gravelly beach.

Some fossil beaches were observed, rising several meters above the lake. The gravel was then thinly covered with lichens, and in some cases even supported a scanty growth of flowering plants. A beetle, (37) *Leptura chrysocoma* Kby., was collected on a rose in such a place.

The contents of the drift washed up on the beaches is of some interest as indicating a possible way in which new forms might reach the island. Here were found *Limnaea stagnalis* (19); a dead butterfly, *Anosia plexippus* Linn., (19); some dead ladybugs, *Anatis 13-punctata* Oliv. (21); shells (21); butterflies (21); one snail shell, *Polygyra albolabris* (Say), badly broken but still containing part of the body (39). The vegetable drift (18, 21) included cones or fruits of jack pine, balsam, arbor vitae, and alder.

Sand beaches are formed in the same way and under the same conditions as the gravel beaches already mentioned, but only where the wave action is much reduced by distance from the lake. The principal ecological difference between the two lies in the presence of the sand, affording a fairly uniform surface, and a finer substratum in which various species may live protected from predaceous ants and spiders.

The principal beach studied was at the head of Conglomerate Bay, (*Fig. 4*), and may be described in some detail. The beach was more than 100 meters long, and divided at the middle by a small stream running through it into the bay. One portion was only 2-6 m. wide, and overhung by alders. There the sand was always moist, and the fauna very scanty. The other portion was 10-20 m. wide, fully exposed to the sun, and sloping very gently back to the usual zone of alders. There was some drift wood scattered about over it.

A warm sunny open place like this attracts many casual visitors from the neighboring woods. Three species of butterflies were especially characteristic. *Papilio turnus* (No. 29) was the most abundant. They flew back and forth along the beach at a general height of 2-3 meters, occasionally flying out over the water and dipping into it now and then. They very seldom alighted on the sand. The red butterflies (No. 29) hovered low over the sand but when they alighted chose grass or low shrubs along the margin. No. 29 includes *Pyrameis hunteri* Fabr., *Pyrameis cardui* Linn. and *Basilarchia arthemis* Dru.

The black butterflies were not common (No. 29). They flew rapidly and irregularly over the sand and the edge of the water at a height of 1-3 m. and very rarely alighted. Two other casual visitors were observed but not caught; a redwinged grasshopper which flew over the sand at a height of 2 m., and dragonflies which hovered over the small stream. Both came from, and returned to, the woods.

Peculiar to the beach were small blue butterflies, *Phyciodes tharos* Dru. (No. 29), and two or three species of sand-wasps (No. 31), including *Diodontus* n. sp., *Ammophila* sp., and *Xanthosarus latimanus* Say, which flew rapidly over the surface at a height of about 1 dm. but very rarely alighted. When dead they were preyed upon by ants. One

or two species of flies (No. 31) (*Cynomyia cadaverina* Desv.) were also common.

Crawling over the sand were ants (No. 30), spiders with eggs cases, *Pardosa groenlandica* Thor. (No. 30), and beetles, *Bembidium carinula* Chaud. (No. 30). The latter were very numerous, and included two species. They ran rapidly and irregularly over the sand, and especially the fine gravel just back of the wet margin. When alarmed they try to hide under small pebbles, or sometimes fly a short distance.

A dead shell of *Limnaea stagnalis* (No. 32) was found on the beach, and a dead *Polygyra albolabris* in the small stream (32).

VI. The Rock Beach.

Where the slope of the shore is steep or the action of the waves severe, gravel or sand cannot accumulate, and the bare rock is left exposed. The ecological conditions affecting animal life here are so different from those of the gravel beaches that they require especial mention.

Rising directly from the water they are naturally exposed to the full force of the waves, (*Fig. 3*), which dash upon them to a considerable height, washing away all loose particles and effectually preventing even the most meager formation of soil. Beyond the reach of the waves, rains and drainage water act with greater or less effect in the same way. The vegetation is therefore limited to various species of crustaceous or foliaceous lichens, which are true lithophytes. Even they are absent from the lower portions where the wave action is more continued, and especially where the ice may scrape them off. Higher up the procumbent juniper and *Cladonia* appear and the whole eventually merges into the *Cladonia* clearing to be described next. Some idea of the zonal succession of the different plants may be gained from the following table, showing the heights of the different zones on a rock beach near the Rock Harbor light-house, *Figs. 6 and 7.*

Zone.	Height—feet.	Total height.
Crustaceous lichens	7 ft. 7 in.	7 ft. 7 in.
Foliaceous lichens	4 ft. 9 in.	12 ft. 4 in.
Juniper	4 ft. 0 in.	16 ft. 4 in.
ladonia	6 ft. 7 in.	22 ft. 11 in.
Forest	4 ft. 1 in.	27 ft. 6 in.

The first two zones, to the height of twelve feet above the lake, are included here in the rock beach. Naturally these levels may vary with different localities, being lower in more sheltered places.

Over the lower portion of the beach the fauna is practically without shelter or protection, and in the zone of foliaceous lichens shelter is afforded only to very minute species. There are sometimes small fissures in the rock, but only two species were observed to enter them. During all or part of the day the beaches are exposed to the direct rays of the sun, and the rock consequently reaches a temperature far above that ever reached by the air.

The temperatures observed on July 11 may be given as an example.

Time.	Air at 4 ft. in sun.	Rock surface.	Rock.
9 a. m.	51 ° Fhr.	68 (sun)	88
11 a. m.	58 ° "	61 (shade)	95
1 p. m.	56 ° "	....	100
2 p. m.	56 ° "	94 (sun)	90

The absence of plant growth also tends to limit the number and character of species to predatory forms, and the number of individuals is small.

A small rock beach jutted into the lake near the light-house, and was at most but one meter high. Although sheltered from the waves by an island, it was still completely flooded by even moderate waves. Most of the surface was accordingly without vegetation, but besides the crustaceous lichens there was one species of moss, a few plants of harebell, and several tufts of grass. Five species of insects were found on this beach, four of which were merely casual visitors. Some spiders (No. 46), *Pardosa groenlandica* Thor., wandered upon the rock from the neighboring gravel beach, but finding no rocks to hide under they soon left. Ants (No. 46), *Formica dryas* Wheeler, were rather common, but it was easy to see that they came from, and returned to, the gravel beach. The only food they obtained appeared to be the remains of dead caddice flies. A species of fly, *Hydrophorus philombrius* Wheeler (No. 46), was very common on those parts of the rock which were constantly wet by the waves. They were seldom seen over the dry portions, but remained resting on the wet rocks. This fly was of common occurrence in the uplands and will be mentioned also under other headings. A few stoneflies (No. 46) were found on the wet rocks where the waves struck. The only species confined to the beach was one species of beetle, *Bembidium grapei,* which ran over the surface, hiding from time to time in tufts of moss.

On a smaller rock beach exposed to the full force of the waves were collected a spider (No. 47) and an ant, *Formica dryas* Wheeler (No. 47); a butterfly (No. 47), *Basilarchia arthemis* Dru., was also taken while hovering over the beach.

On a larger beach near by, the elevations of which were given in a preceding paragraph, the fauna was better developed. A jumping spider was fairly abundant, and was a fine example of protective coloration, being almost invisible against the gray rock background. Another spider (No. 48) and red mites (No. 48) hid under the foliaceous lichens. A small beetle (No. 48) was abundant, running rapidly over the rock, never attempting to fly, but hiding in the crevices. A brightly colored red and black beetle was common. It ran rather slowly but flew easily. No ants were seen. Besides the forms just mentioned, which may be considered normal members of the rock beach association, there was collected a caddice fly (No. 48) and a running spider (No. 48), undoubtedly a straggler from the Cladonia zone above.

At other times were collected on rock beaches ants, (No. 15) *Camponotus herculeanus* L., carrying away dead caddice flies, and as accidental visitors a *Cimbex americana* Leach (No. 106), a butterfly (No. 107), *Basilarchia arthemis* Dru., and a running spider (No. 103), *Lycosa pratensis* Emer.

In connection with the rock beaches may be mentioned the beach pools (*Fig. 5*), which are depressions in the rock filled with water by high waves. They are naturally most abundant on flat or gently sloping beaches, and their permanency varies with their size and depth, affecting evaporation, and with their height above the lake, affecting the frequency with which they are filled. In those which are permanent are found shells, *Limnaea emarginata* Say (No. 58), and *Planorbis parvus* Say (No. 59), and a few insects, *Rhantus binotatus* Harr. and *Corixa* sp. (73, 74, 75). The water beetles and water boatman are strongly stereotropic, staying on the bottom or in crevices, and leaving it only to dart quickly to the surface for air.

VII. The Cladonia Clearing and Jack Pine Ridges.

The elevated position of the rock ridges and their physiographic relation to the uplands are the two chief factors determining the succession of biota upon them. In response to the rapidity of drainage, and the slowness of soil formation the first plant life to invade the rock beaches is a lichen association composed to a large extent of *Cladonia rangiferina*, which carpets the rock to a thickness of 1 to 3 dm. With it are associated various xerophilous shrubs and herbs, but no trees. Consequently the insolation is strong, and after rains that water not removed by surface drainage is soon evaporated. The soil consists only of those thin deposits formed by the disintegration of the underlying rock and the decay of the vegetation, and is held in place by the tufts of lichens. Such natural clearings in the forest are frequent near the lake (*Figs. 6, 7, 9*), either on gentle slopes but little above the lake and consequently of late origin, or upon the elevated rock ridges (*Figs. 8, 25, 26*), where they are of much greater age. Their shape and size varies naturally with the topography.

In these Cladonia clearings has been developed a very characteristic faunal association, rich in species and in individuals, and especially distinct in the number and variety of insects. The fauna may be conveniently divided for discussion into three groups, aerial, terrestrial, and subterranean. Since the latter is the most nearly fixed in habit, it may be described first.

1. *Subterranean Fauna.* In the shallow depressions and crevices of the rock (*Figs. 7, 25, 26*), are thin soil deposits supporting a dense growth of various plants, especially the Cladonia lichens, the bearberry, and dwarf juniper. Ants are frequent, running over the surface and excavating below it, but they make their nests only in the deeper crevices or under the densest growth of plants where the depth of soil is sufficient to allow them to make their excavations and to conserve the moisture supply. In the crevices they are usually 1 dm. or more below the surface. *Camponotus herculeanus* L. (22), *Myrmica rubra* L. (61), and *Leptothorax canadensis* Prov. (63) are the species generally represented. The nests are more frequent near the margin of the rock clearings,

where the soil is better shaded. A nest of *Formica sanguinea* Latr. (No. 72) was placed under a decaying limb, and the soil beneath it was largely composed of minute fragments of rotten wood. This ant has two sorts of pupa cases. Another colony, *Leptothorax canadensis* Prov. (No. 77), was also collected in Cladonia clearings.

The largest species of ant (No. 62), *Camponotus herculeanus* L., is found always singly, and no nests were ever observed.

Spiders also occur in the looser soil deposits, but most of them probably belong to the surface, such as (No. 71) *Lycosa kochii* Keys, which had an egg case attached, although buried under two cm. of soil. The largest spider, (No. 67) *Coelotes* sp. of which only one specimen was observed, is apparently entirely subterranean. It spins a pocket just about large enough for its own body, and when uncovered does not attempt to run, but buries itself in the soil or in crevices. A third species was a mite (No. 64), *Rhyncholophus simplex* Bks.

Other species are found in fewer numbers, such as the fishworm (No. 70), in soil under bearberry at a depth of 5 cm.; a shell, *Zonitoides arboreus* Say (No. 65); myriapods (No. 64), and a few other insects, including beetles, beetle larvae, and one Jassid (No. 64).

2. *Terrestrial Fauna.* Aside from the ants, which I have included in the first group, shells, spiders and grasshoppers are the most important members of this fauna. Of the former but one species is included, *Polygyra albolabris* Say. It was not seen alive, but their dead shells are abundant on nearly every Cladonia clearing as well as the drier forest covered ridges (Nos. 20, 33, 88, 93, 138, 145, 174, 197). The live ones are also found in damper places or even in swamps (No. 113).

Spiders were numerous especially in the clumps of Cladonia, where they crawled over and under the mats, frequently carrying egg cases. Three species were observed, *Gnaphosa brumalis* Th., *Pardosa sternalis* Th., and *Lycosa kochii* Keys, (all No. 22).

During the first part of July grasshoppers were infrequent, except the wingless stages, but during the last part of the month and in August they were extremely abundant. They are not confined to clearings with a copious growth of Cladonia or other vegetation, but are equally abundant on the most barren rock-ridges. Immature specimens of *Chloealtis conspersa* Harr. (No. 22) were hopping over the lichens on July 6.

Mature forms of *Melanoplus huroni* Blatchl. and *Circótettix verruculatusKby.* (No 44, 35, 108, 131, 132), were very abundant. They fly well, making a clicking noise the while, and very rarely leave the sunny open ridge. *Chloealtis conspersa* Harr. (Nos. 143, 144) was collected in similar places from *Prunus pennsylvanica, Diervilla,* and *Coptis trifolia,* and the grasshopper *Melanoplus alaskanus* Scudd, (Nos. 146, 147) was taken on *Gnaphalium, Diervilla* and grass.

3. *Aerial fauna.* The light and warmth of the Cladonia clearing attracted many flying species, including the cicada, *Tibicen rimosa* Say, *var.* (44, 108, 111); bees, *Monumetha albifrons* Kby. (68), *Xanthosarus latimanus* Say (68, 108), *X. melanophea Sm.* (108); the dragonflies, *Aeschna* (No. 69), *Ophiogomphus colubrinus* and *Tetragoneuria spinigera* Say (132); the butterflies, *Papilio turnus* Linn. (97), *Basilarchia arthemis* Dru. (97), *Argynnis myrina* Cramer (97), and *Argynnis atlantis* Edw. (32), and hosts of blackflies, *Simulium venustum* Say.

The butterflies, *Basilarchia arthemis* Dru. and *Argynnis atlantis* Edw., are so characteristic of these clearings that we knew them by the common name of "clearing" butterflies. The blackflies are abundant, and are preyed upon by dragonflies, probably the chief reason for the occurrence of them so far from the swamps.

Of particular interest was the small fly, *Hydrophorus philombrius* Wheeler, mentioned before in connection with the rock beaches. They were numerous over all the clearings, but they settled in especial abundance on the moist newly exposed soil which I uncovered. It is probable that they do this only for the moisture or coolness, but in one case a number of them swarmed over the pupa case of an ant, (No. 66).

Of especial interest was the fauna of the large complex of Cladonia clearings just behind the camp at Siskowit Bay (V, 3), *Figs. 24, 25, 26.* There was a uniform gentle slope from the margin of the bay back some distance inland, on which large areas were occupied by the usual growth of Cladonia, juniper and bearberry. The whole was surrounded and intersected by balsam and spruce forest.

Shells were quite rare, although a few of the usual species, *Polygyra albolabris* (Say) (233), were collected.

The subterranean species of ants so common about Rock Harbor were not observed. They were replaced by another species, *Formica fusca* L. (223, 224, 226, 227), which built large circular flat-topped nests (*Fig. 28*), 5 to 8 dm. in diameter, composed of earth and vegetable debris and covered with debris of balsam and spruce needles. Two sizes, a larger (223) and a smaller (224), were sometimes associated in the same nest. Many nests had been almost completely destroyed by the pileated woodpeckers. Spiders, *Pardosa sternalis* Th. (No. 225), were frequently seen crawling over the ant's nests. Other spiders crawl over and through the *Cladonia,* dragging egg cases behind them, and crawling into holes and crevices.

Grasshoppers were abundant, as usual. Some short winged nymphs of *Melanoplus fasciatus* Barnst-Walk., (No. 208) were taken in thickets of *Juniperus nana.* They usually hide down in the juniper and will not jump out if frightened, but crawl down close to the ground, so that they are practically invisible. When once seen they can be picked up with the fingers. Sometimes they leave the clumps of juniper and jump or fly out over the *Cladonia* and rocks. These flights seldom exceed 1-2 m. in length, but on one occasion one flew 6 m. high and disappeared among the balsam trees. The adults of the same species (193, 201, 208, 214), with full length of wings, fly long distances at a height of 3-7 m. or more, making the usual clicking noise. They alight only on the bare rock or on short *Cladonia*, avoiding the other vegetation. One fiddling grasshopper, *Camnula pellucida* Scudd. (No. 228), was also taken from mats of the juniper.

Bumblebees, particularly *Bombus terricola* Kby. (208), visited the flowers of *Diervilla and Melampyrum.*

Other bees, including *Tenthredopsis nebelloides* McGill, *Coelioxys moesta* Cr., *Xanthosarus melanophea* Sm., and *X. latimanus* Say, visited the same plants.

A small carabid beetle, *Carabus serratus* Kby. (No. 208), crawls over and through the Cladonia, foraging. *Leptura chrysocoma* Kby. (208) was taken in the same locality.

The yellow clearing butterfly, *Basilarchia arthemis* Dru. (208), is very common, flying in regular paths up and down the clearing at a height of about one meter, sometimes alighting on the ground and sometimes on the flowers of *Opulaster*.

Urocerus flavicornis Fabr. and *U. flavipennis* Kby. (208, 209, 228) were especially common. They fly low, usually 2-3 feet above the ground with a moderate but uniform velocity. They are searching for balsam trees in which they deposit their eggs, and were sometimes taken crawling over the trunks.

A small brown wasp flies low over the ground like an asilid.

Asilid flies, *Asilus annulatus* Will. (208), fly low, 1-2 ft. above the ground, alight on tufts of grass or *Cladonia* and crawl down into it. It could not be determined what they were hunting.

Three species were taken on the flowers of the harebell, *Campanula rotundifolia*. They were *Coelioxys nivesta* Cr., *Xanthosarus melanophoea* Sm. and *X. latimanns* Say. Insects were more numerous on the flowers of *Opulaster*, from which were collected *Tenthredopsis nebelloides* McGill, *Prosopis* sp., *Argynnis atlantis* Edw., *Eristalis dimidiatus* Wied., *Phormia terraenovae* Desv., *P. regina* Meis, and *Hyetodesmia serva* Meis.

A wasp, *Eutypus americanus* Cress. (235), was found backing over the ground dragging a spider, *Lycosa kochii* Keys. At brief intervals it dropped the spider and ran rapidly back and forth looking for the hole to which it was taking its capture. It seemed to have a general idea of its location, but had to crawl always exactly to it. Having found it, a similar search was begun for the spider, and then the journey was resumed in a direct line toward the hole.

The typical *Cladonia* clearings just described were almost invariably on the lower ridges or gentler slopes. They were surrounded, and eventually entirely covered, by the balsam-spruce forest. On certain of the higher or steeper ridges, there was another intermediate stage in which the clearings were covered with jack pine. This was due apparently to their position; the formation of soil was slower and the drainage better, so that, even with a considerable depth of soil they were still too dry for balsam or spruce, and were accordingly occupied by the xerophile jack pine. In general ecological conditions they were but little different from the treeless associations. The ground vegetation was, as usual, *Cladonia* or bearberry, and the forest cover was scarcely heavy enough to make much shade. But the mere presence of trees indicates that there was a greater deposit of the soil. Under the bearberry and Cladonia, the soil was quite thin, but there were more loose rocks, and larger and deeper fissures, which were filled with soil. The effect on the fauna was to increase the number of subterranean species and diminish the number of aerial forms.

In the soil deposits up to 5 cm. deep there is practically no animal life, although ants crawl over the surface. Nests of *Lasius niger* L. are common in crevices and under loose stones at a depth of 1 dm. or more (Nos. 79, 82). A nest of *Lasius niger* L. (No. 83) was excavated under and at the side of a large stone. The stone formed the roof of shallow excavations where the pupae were stored, and the vertical wall of earth at the side was honeycombed with rounded passages 1-2 cm. high, 2-4 cm. broad, and separated by thin partitions. Under larger stones their

nests may be built at less depth, as one of *Formica fusca* L. (No. 100) at a depth of 4 cm. These loose rocks tend to conserve the moisture just as do the crevices.

Beetle larvae are rarely found, owing to the abundance of ants which feed upon them. They occur under rocks or in the deepest soil deposits where the moisture is conserved. (Nos. 80, 82, 102.) No. 102 contains two species of larvae, one a Cistelid, the other *Drasterius* sp. The latter when collected had been captured by an ant, *Formica fusca* L. (No. 102). A dead beetle, *Dipolataxis liberta* (102), was collected under a flat rock.

Spiders are abundant, especially *Drassus neglectus* Keys (No. 101), *Cicurina arcuata* Keys (No. 102), and *Lycosa pratensis* Emer. (103). The former builds a small pocket-like web 2 by 3cm. in cavities under rocks, at a depth of about 1 dm. Spider egg cases were frequently found under stones or in rotten wood (No. 102).

Myriapods were rarely seen. They seem to have regular runaways excavated through the wood or soil (No. 103). A dead caterpillar was also found under a rock (No. 102).

Besides the numerous dead shells of *Polygyra albolabris* Say (Nos. 23, 27, 81, 187) which are common on the ground, especially near dead logs, others were taken below ground. They occur at a depth of 1-2 dm. under angular rocks, or at a less depth under larger flat rocks. In either case their presence seems to be controlled by the moisture (Nos. 81, 102). Other shells were also rather common under rocks, especially flat ones at a depth of 1 dm. or less (81). This single collection included *Pyramidula cronkheitei anthonyi* Pils., *Zonitoides arboreus* Say, *Vitrea binnojana* (Nise), *Strobilops virgo* (Pils.). Under angular rocks down to a depth of 1.5 dm. *Pyramidula cronkheitei anthonyi* (Pils.) and *Zonitoides arboreus* (Say) were found. There are very rarely more than one under each stone. Most of them were dead, and the shells were frequently broken, but a few were alive. At but one place were they associated with a *Polygyra*, and in this case the *Polygyra* was sealed with a membrane across the orifice and was probably still alive. No shells were ever found under rocks with ant's nests.

One jumping spider, *Lycosa pratensis* Emer. (103), was caught on a dead jack pine tree, 6 dm. from the ground.

The fly (*Hydrophorus philombrius* Wheeler) already observed on beaches and clearings was again common. Ordinarily they fly about near the surface in the sunniest places, alighting on the ground or on low plants. As soon as any moist soil is exposed they congregate on it in numbers, crawling over the surface, into ant burrows, and even apparently attempting to eat the ant pupae. One species of ant was seen catching them.

Among other insects were bumblebees, *Bombus* sp. (23), visiting the flowers of *Diervilla diervilla*; grasshoppers *Circotettix verruculatus* Kby. (27); cicadas, *Tibicen rimosa* Say, var. (28, 84), frequent in the pine trees.

VIII. The Balsam-Spruce Forest.

The ultimate tendency of all plant associations on Isle Royale is toward the balsam-spruce forest. The succession is sometimes direct, sometimes indirect; sometimes rapid, as upon the smaller Cladonia

clearings; sometimes slow, as upon the jack-pine ridges. Just as all temporary plant associations are occupied by definite faunas of a composition largely dependent on the plant covering, so the climax association of plants is also accompanied by a definite fauna, which must likewise be regarded as the climax animal association.

The succession of the dense forest growth brings into play a number of new ecological factors, which are not only of the highest importance in controlling the animal life, but are also retroactive upon the plant covering itself. In all the associations heretofore described physiographic changes have been proceeding with comparative rapidity. They may be due to wave action, drainage, elevation, rock disintegration or soil formation as direct agents, or to changes in the soil composition, soil moisture, light, or heat through the indirect agency of the vegetation. Corresponding to the wide diversity in physical conditions there has been developed a fauna of many species adapted to many different modes of living. Through the agency of the forest cover the light is reduced to a constant minimum, the temperature is made more uniform, the soil becomes of uniform character throughout, and the moisture is kept nearly constant. Indirectly the diffuse light is normally too weak to allow the growth of a ground cover of herbaceous plants so that the variety of food supply is reduced. In short, the change is from heterogeneity of ecological conditions to homogeneity, and the number of species varies directly with the heterogeneity of the habitat. This is true not only for Isle Royale, but for any biotic association. Here, however, the homogeneity is especially marked; because two species alone, the balsam fir and the white spruce, are dominant throughout.

The soil in the balsam-spruce forest is a damp closely packed leaf mold, sometimes deep, sometimes shallow over the rocks, and composed of decaying balsam and spruce needles, mixed with decaying sticks and interwoven with fungus mycelium. When the forest is not so dense aspen and birch trees may be growing, and their leaves also mix in the mould. In such places there may be a very thin ground cover of *Aster macrophyllus*, *Linnaea americana* and *Pyrola chlorantha;* otherwise the soil is without cover. Above this rises the dense growth of trees, the younger ones and the lower branches stunted or dead from lack of sufficient light.

The insect fauna is composed almost entirely of subterranean species, all few in number, and mostly colorless. A few species of spiders are seen, and a minute Collembolan, *Tomocerus niger* Bourl. (No. 140). Two species of myriapods (No. 140) are rather abundant in the mould, one other larger species was seen once (No. 140), and an *Enchytraid* earthworm (No. 140). A few species of small shells are rarely found at depths of about 5 cm. or sometimes on the surface. They are *Pyramidula striatella* (Anth.), *Zonitoides arboreus* (Say), *Vitrea binneyana* (Nise), and *Ancylus* sp. (140).

There are no ants except a large black species which forages singly over the surface, *Camponotus herculeanus* L. (No. 140). A single black Carabid, *Calthus gregarinus* Say (No. 140, 236), also runs over the surface and hides under old balsam cones.

A few species of flying insects occur, especially mosquitoes, and when

the fresh mould is turned over a few of the moisture-loving flies, *Hydrophorus philombrius* Wheeler, appear and rest on the moist exposed surface.

The trees themselves shelter a more varied population. Most of the Buprestids and Cerambycids caught in the tent probably came from the forest. The dead trees of balsam or spruce are attacked by wood-boring larvae, which construct a network of chambers just between the wood and bark. Some of these turn into the wood and extend to the center, following a longitudinal or tangential path for most of the way. These holes may be filled with dust part of the way, but the greatest portion is empty. They are about 3 by 5 cm. in diameter, of an elliptical shape, but at the ends sometimes widen out into chambers a couple of centimeters broad. Two species of larvae occupy these burrows (No. 205), and in one was found a small spider, *Amaurobius bennetti* Blk. (No. 205).

Under the loose bark of trees which have decayed further spiders, *Amaurobius bennetti* Blk. (No. 205), frequently build their webs. A beetle, *Calathus advena* Le C. (No. 142), forages here for food, and in one case a shell (142) was taken. A nest of *Formica sanguinea* Latr. (No. 78) was found in the rotten wood of a fallen tree, but the ants probably foraged over a rock clearing near by rather than in the forest. In prostrate decaying logs the fauna is not different from that of the leaf mold, and the same species were collected.

A number of the mushrooms of the genus *Pleurotus* were collected on dead trees and they were inhabited by large numbers of beetles (229) *Tritoma thoracica* Say, T. *macra* Lec., *Boletobius cincticollis* Say, and *Gyrophaena* sp.

IX. Artificial Clearings.

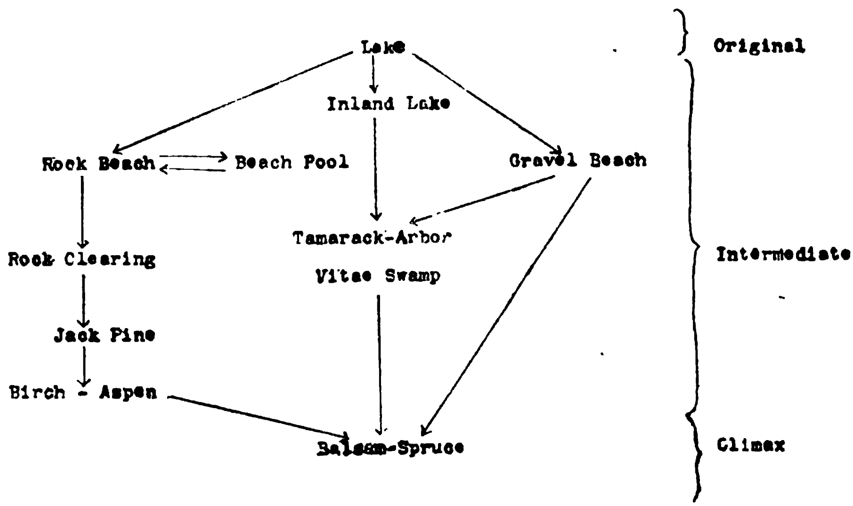
The clearing about the camps both at Rock Harbor and at Siskowit Bay attracted many species of insects, particularly strong fliers, such as Hymemoptera, Lepidoptera and Diptera. At Rock Harbor Cow-parsnip, *Heracleum lanatum,* introduced in the island some way, was in bloom and it attracted a number of species of bees and flies.

In a similar clearing on the north side of Rock Harbor a number of shells were collected from the under side of dead logs (150). Some of these were observed at no other place. They included *Polygyra albolabris* (Say), *Acanthinula harpa* (Say), *Bifidaria tappaniana* (C. B. Adams), *Zonitoides arborea* (Say), *Pyramidula cronkheiti anthonyi* Pils., *Cochlicopa lubrica* (Müll), and *Vallonia costata* (Müller). A plant of *Opulaster* blooming in the same clearing attracted a multitude of insects (148), including the flies *Platychirus peltatus* Meigen, *Syrphus zennalis* Williston, *Sphaerophoria cylindrica* Say, *Eristalis dimidiatus* Weed and *Temnostoma aequalis* Loew; the bees *Halictus versans* Lowell, *Xanthosarus latimanus* Say, and *Bombus terricola* Kby; the beetle *Leptura chrysocoma* Kby. and the lepidopteron *Cupido sepiolus* Bd.

X. Summary.

From the lake, representing the most primitive habitat, there are three lines of development culminating in the climax association; first,

through the tamarack swamp and peat bog; second, through the gravel beach and arbor vitae swamp; third, through the rock beach and Cladonia clearings. Physiographic forces have some direct part in causing the successive changes in ecological factors, but most of them are due to the retroaction of the vegetation upon the habitat. The first stages of the series are marked by a severity of conditions which limit the fauna to a few well adapted species. The intermediate stages have generally a wide variety of conditions, leading to the development of a varied fauna. The most noteworthy in this respect is the fauna of the Cladonia clearings. The ultimate or climax stage is homogeneous because of the dominance of a few species, and the fauna is again limited to a few well adapted species.



THE ECOLOGICAL DISTRIBUTION OF THE BIRDS OF ISLE ROYALE, LAKE SUPERIOR.

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I. INTRODUCTION.

In this report I shall discuss the habits of the different birds and their relation to their environment as found upon Isle Royale. The different localities visited will be described, the birds listed as found in each locality, and the details of their habits and distribution described.

On account of the limited time, I was unable to examine a large part of the island, but representative localities were visited, so that a general idea of the bird life of the island can be gained from this report. For example, a number of tamarack swamps were visited and certain birds were found in each of these; it therefore seems reasonable to infer that these birds are found in the many other tamarack swamps which were not visited.

Observations were made in five different localities by members of the Museum party, but only those visited by the writer will be described. In connection with this paper the "Annotated List of Birds" should be consulted. These localities will be taken up in the following order:

1. Light-house Peninsula.
2. Trail to McCargoe Cove.
3. West End of Rock Harbor and Trail to Summer Lake.
4. Siskowit Bay Region.

II. LIGHT-HOUSE PENINSULA.

This station included the land between Conglomerate Bay and Rock Harbor. The conditions in this small strip of country varied very much, and on this account it will be divided into a number of stations as follows:

1. Lake Superior and Beach (Station I, 1).
2. Spruce and Balsam Forest (Station I, 2 and 3).
3. Tamarack and Arbor Vitae Swamps (Station I, 4).
4. Jack Pine Ridge (Station I, 5).
5. Sphagnum and Spruce Bog (Station I, 6).
6. Valley at Head of Conglomerate Bay (Station I, 1).

1. Lake Superior and Beach (Station I, 1).

This station included the whole of Tonkin and Conglomerate Bays and that portion of Lake Superior and Rock Harbor which could be seen from the light-house. The water was deep, cold and contained very little vegetation. The shore bordering the lake was composed of jagged, desolate, wave-washed rocks (Figs 2, 5), and only in the

most protected portions of the bays and harbors were trees found growing near the edge of the water (Fig 4). This accounts for the fact that no shore birds or vegetable feeding water fowl were observed here.

The birds seen in this station were as follows: Herring Gull, Loon, American Merganser, Hooded Merganser, Spotted Sandpiper, Song Sparrow, Myrtle Warbler, Olive-backed Thrush, Crow and Osprey.

The Herring Gull was the only bird seen on the water in large numbers. At almost any time of the day there were fifteen or twenty in sight, and sometimes they came in large flocks to eat the refuse thrown along the shore of Rock Harbor by the fishermen. Seventy-seven were once counted, and occasionally the number was greater.

When not feeding on the water they passed the time soaring in the air or resting on the bare rocks. They seemed to prefer soaring during windy weather. With the head toward the wind they would move slowly upward and forward for some time, then turn suddenly and soar away with the wind at a rapid rate, then swing around in a graceful curve and again mount upward.

The American Merganser, Loon and Hooded Merganser were occasionally seen on the water. On July 27 and 28 a female Hooded Merganser and six young were observed. These ducklings were yet small and could be overtaken with a row boat, but when pursued they escaped by diving.

Thus it will be seen that, excepting the Gulls, water birds were scarce and the shore birds nearly lacking. Only one shore bird, the Spotted Sandpiper, was seen and that was observed two or three times; this was probably a migrant. The other birds seen on the shore, were the Crow, Myrtle Warbler, Song Sparrow, and Olive-backed Thrush. They occasionally came from the bushes and forests to feed there. Of these birds the Song Sparrow was seen the most often, and almost every morning could be heard singing on the small rocky islets partially covered with bushes, which lay just east of the light-house.

2. *Spruce and Balsam Forest* (*Station I, 2-3*).

In this forest of spruce, balsam and birches, there were many low rock ridges whose tops were almost destitute of soil and trees, thus forming a long, narrow, natural clearing of not more than two hundred yards in length and from thirty to sixty yards in width (*Fig. 8*). Near the light-house there were five of these ridges from thirty to two hundred yards apart; while farther to the west there were more of them, but they were farther apart.

On account of these openings in the forest, there were many birds here that frequented partial clearings, yet no birds that inhabit large tracts of cleared land, except the Chipping Sparrow, which occurred in the small clearing at the light-house.

The birds found under these conditions were as follows: Red-breasted Nuthatch, Chipping Sparrow, Nashville Warbler, Black-throated Blue Warbler, Black-throated Green Warbler, Chickadee, Flicker, Golden-crowned Kinglet, Bay-breasted Warbler, Crow, Myrtle Warbler, Sparrow Hawk, Magnolia Warbler, Wilson's Thrush, Olive-backed

Thrush, Pine Siskin, Purple Finch, White-throated Sparrow, Tree Swallow, Barn Swallow, Sharp-shinned Hawk and White-winged Crossbill.

The Purple Finch, Pine Siskin, Sparrow Hawk, Sharp-shinned Hawk, Bay-breasted Warbler, Black-throated Blue Warbler, Tree Swallow and Barn Swallow were only occasionally seen.

Some of the Warblers were common, and it was interesting to note the difference in the localities which they frequented. The Myrtle Warbler was most frequently seen near the shore. The Magnolia Warbler frequented the small spruce and balsam trees but was not seen on the shore. The Black-throated Green Warbler was always observed in that part of the forest where there were many birch trees, and the Nashville kept near the partial clearings.

Nests of the Myrtle Warbler, Chickadee, Golden-crowned Kinglet, Olive-backed Thrush and Chipping Sparrow were found in this locality. The nest of the Myrtle Warbler was found July 7, on a small jack pine standing near the edge of a rocky cliff, which rose perpendicularly from the water to a height of about twenty feet. It was composed of small twigs, dried grass and pine needles, and contained four young about a week old. While we were near, the old bird approached the nest very cautiously. It would fly from tree to tree until within about fifty feet of the nest and then drop down near the ground and fly low until below the nest; when leaving it flew along the edge of the cliff.

On the same day a Golden-crowned Kinglet was seen to take a bit of moss and fly into a clump of stunted spruce trees on a rock ridge. The tops of the spruce were so thick and bushy that it was impossible to see the nest from the ground, although the tree was not more than twenty-five feet high. On climbing the tree a half finished nest was found built mostly of green moss. By July 21 the nest was finished and contained eight small eggs. This beautiful mossy cup was about four inches in diameter and of the same depth, but the cavity containing the eggs was still smaller, as the wall of the nest was about two and a half inches thick and lined with hare fur.

In front of the light-house at the edge of the beach, stood a small spruce about twenty feet high, on a horizontial limb of which was the nest of a Chipping Sparrow, composed entirely of grass. When the nest was found on July 5 it contained four young that had evidently just hatched.

An Olive-backed Thrush's nest was found July 8, in a low limb of a spruce that stood near the shore. It was found five feet from the ground, composed of grass and moss, and contained three very young birds. The old bird would not approach while I was near the nest and was so shy that the true owner of the nest was difficult to determine. Probably more nests would have been found had we arrived upon the island earlier, as many young were able to fly when we came, and several immature Magnolia Warblers were found at that time in the bushes near the light-house.

Birds were more abundant in this locality than in any other of the same size. Why this was true, I did not determine.

3. *The Tamarack and Arbor Vitae Swamps* (*Station I, 4*).

This almost impenetrable swamp of cedar and tamarack, situated at the head of Tonkin Bay, extended back about a quarter of a mile toward the southwest. To cross this swamp was difficult on account of the fallen trees and numerous low branches, but a rock ridge extended from the bay through the middle of the swamp, almost to its western end, and furnished a convenient route into it. This ridge influenced the bird life of the vicinity because of its different ecological conditions. It was bare in places, but most of it was partially covered with birch, spruce and balsam.

The birds seen in this swamp habitat were as follows: Nashville Warbler, Red-breasted Nuthatch, Chickadee, Black-throated Green Warbler, Raven, Brown Creeper, Yellow-bellied Flycatcher, Hairy Woodpecker, Winter Wren, Black-throated Blue Warbler, Flicker and Canada Jay.

On July 11, nests of the Black-throated Green and Nashville Warblers were found on the north slope of the ridge within twenty-five yards of each other. The nests of the Black-throated Green was in a cedar tree about twenty feet from the ground. It was composed of grass, moss and twigs and contained young. The nest of the Nashville Warbler was in a cavity in a thick bed of moss which covered the face of a small cliff five or six feet high. Here, in a soft nest composed of lichens and lined with grass, were found five young in the down.

These two birds acted very differently when one was near their nest. The Black-throated Green would come within less than ten feet of the observer and scold while moving restlessly about among the branches. The Nashville Warbler was not as bold, for it remained up in the tree tops. It would hop on a branch, turn around a few times, turn anxiously toward the nest and then repeat the performance; but it never uttered a sound. Here was one of the difficulties in judging what localities birds preferred. These two birds nested on the slope of a rock ridge and fed in a cedar and tamarack swamp. To which did they belong? However, judging from other observations, I would say that if the natural clearing had not been here the Nashville Warbler would not have been found, while the Black-throated Green might have been.

The Black-throated Green, Black-throated Blue and Nashville Warblers, Chickadee, and Red-breasted Nuthatch were nearly always found in this swamp, and these were in the more open parts where the trees were not so close together. I visited the thickest part of the swamp many times without seeing a single bird.

4. *Jack Pine Ridge* (*Station I, 5*).

This habitat was on the north side of Conglomerate Bay and composed a portion of the south side and the top of a hill about 100 feet high. The side of the hill was dry and rocky, and was partially covered with scattered aspens and clumps of jack pines (*Fig. 13*). Where there were no trees the ground was partially covered with mosses, lichens, bearberries, golden rods, etc. The top of the hill was bare rock with jack pines and a few plants growing in the crevices. Occasionally there was a small gully with other trees growing in it.

On account of the desolate character of this locality few birds were found here. A Cedar Waxwing's nest containing five eggs was found July 10. Juncos and White-throated Sparrows were occasionally heard singing among the jack pines.

5. *Sphagnum and Spruce Bog.* (*Station I, 6*).

This small bog, situated on top of the hill north of Conglomerate Bay, was covered with sphagnum moss and bushes with several black spruce trees scattered over it. There were also several tamaracks and spruce at the edge of the bog. (*Fig. 14*). The birds seen here were: Golden-crowned Kinglet, White-throated Sparrow, Cedar Waxwing, and Black-throated Green Warbler. The Oven Bird and Wilson's Thrush were heard in the forest near by.

6. *Valley at Head of Conglomerate Bay* (*Vicinity of Station I, 1*).

This location included the alders and the partial clearing at the mouth of the brook that emptied into the head of Conglomerate Bay. The partial clearing, evidently due to fire, as blackened logs were still lying around on the ground, was covered with weeds, raspberry bushes, dogwoods and clumps of small birches.

The birds seen here were: White-throated Sparrow, Canadian Warbler, Redstart, Flicker, Winter Wren, Chickadee, Nashville Warbler, Magnolia Warbler, Olive-sided Flycatcher, Olive-backed Thrush, Sparrow Hawk and Cedar Waxwing. The Redstart and Magnolia Warbler seemed to be restricted to certain parts of this locality. The Redstart was always seen among the alders, while the Magnolia Warbler kept among a patch of evergreens at the foot of the hill on the north side of the habitat.

III. TRIAL TO MCCARGOE COVE.

This station included the country along the trail which ran from Rock Harbor to McCargoe Cove. This trail started on the north side of the harbor at the mouth of Benson Brook which it followed nearly to Lake Benson, then it crossed the hills to Sargent Lake and from there it went to McCargoe Cove. As I did not make any observations north of the Greenstone Ridge, I will only describe that portion of the country between Rock Harbor and the top of the Ridge. In this portion there were several different conditions which will be described in the following order:

1. Ransom Clearing (Station II, 1).
2. Benson Brook (Station II, 1).
3. Spruce and Tamarack Swamps (Station II, 2 and 5).
4. Rock Ridge Clearings (Station II, 3).

1. *Ransom Clearing* (*Station II, 1*).

This small clearing on the lowland at the mouth of Benson Brook was covered with grass and large clumps of alders, birches and aspens. These bushes scattered through the clearing formed an excellent habitat for birds, and, although the clearing was small, thirteen species were observed here. They were as follows: Black-billed Cuckoo, Canada Jay,

Song Sparrow, Alder Flycatcher, White-throated Sparrow, Redstart, Red-eyed Vireo, Cedar Waxwing, Wilson's Thrush, Olive-backed Thrush, Sparrow Hawk, Purple Finch and Pine Siskin.

Every time this station was visited there were one or two Alder Flycatchers among the alder bushes, sometimes on top of the highest bush and sometimes near the ground. They seemed to be always on the lookout for insects, and every few minutes they would fly several feet into the air and a snap of the bill told that some insect had been caught. They could often be located by their "pep" of alarm, and in the morning I frequently heard them sing a short song.

The Redstart and Nashville Warbler were often seen among the alders also. Both were always on the move. The Redstart kept flitting from branch to branch, only pausing an instant at each one to look for insects, while the Nashville Warbler would light on a limb and start to hop toward the top, looking an instant at each leaf as it passed.

2. *Benson Brook (Station II, 1).*

The conditions along this little brook are difficult to describe in a general way because they were so diverse; every few rods there was a change. The little stream meandered through dense forests of cedar, spruce and birch; through thickets of alders, dogwoods and small maples; rushed through narrow ravines between bare topped ridges, over rocks, through forests of birch and aspen until it finally reached the harbor at Ransom clearing.

The birds found along this brook were the White-throated Sparrow, Redstart, Winter Wren, Red-eyed Vireo, Cedar Waxwing, Oven Bird, Sparrow Hawk, Wilson's Thrush, Olive-backed Thrush, Blue Jay, Canada Jay, Crow, Purple Finch, Sharp-tailed Grouse, Grinnell's Water Thrush, Flicker, Magnolia Warbler, Hairy Woodpecker, Nashville Warbler, Red-breasted Nuthatch, Golden-crowned Kinglet and Chickadee. The Sparrow Hawk, Blue Jay, Flicker, Sharp-tailed Grouse, Cedar Waxwing and Purple Finch were seen more often in the clearings where there were berries, grasshoppers and other insects. The Winter Wren and Water Thrush were always seen near the brook. The former frequented places where the undergrowth was thick. It was often observed flying along the brook and stopping every few yards to look under the leaves and logs for insects, and one was shot with a spider (*Amaurobius bennetti* Blk.) and two mosquitos in its mouth. Sometimes this shy bird would venture away from its damp retreat, perch upon the top of a tree and pour forth a melody that rivalled any song heard in these woods.

The Oven Bird and Red-eyed Vireo were nearly always found among the birches and aspens. The former very frequently was flushed from among the honey-suckle bushes on the ground, but the Vireo was always in the trees. The Magnolia Warbler, Red-breasted Nuthatch, and Golden-crowned Kinglet were always seen in that part of the forest where there were several spruce or cedar trees.

A large number of different species of birds was observed in this habitat, but that was because it was so large. In reality the country was rather desolate, for with the exception of some damp places along the brook, the original forest has all been burnt off and was only partially replaced by a second growth of birch and aspen.

3. *Tamarack and Spruce Swamps* (*Station II, 2 and 5*).

About a quarter of a mile north of Benson Brook there was a swamp similar to I, 5, except that it was larger and had more spruce and tamarack trees scattered through it. The ground was covered with sphagnum, Labrador tea, pitcher plants, etc., but apparently nothing that would attract birds except the trees.

The birds seen here were the Red-breasted Nuthatch, Marsh Hawk, Junco, Canada Jay, Black-throated Green Warbler, Black-throated Blue Warbler, Chickadee, Golden-crowned Kinglet, White-winged Crossbill, Yellow-bellied Flycatcher, and White-throated Sparrow. The Junco probably strayed here from a large rocky clearing near by, as only one was seen in the swamp, but it was heard in the clearing every time I visited it.

About a quarter of a mile further on toward Greenstone Ridge, the trail crossed another swamp similar to this one, though it was somewhat longer. Since the conditions were the same in these two places, many of the same birds would be expected to occur in each, and this was the case as will be seen by comparing the list given above with the following: Olive-sided Flycatcher, Red-breasted Nuthatch, Nashville Warbler, Canada Jay, Chickadee, White-winged Crossbill and Golden-crowned Kinglet.

Near Forbes Lake there were two other swamps and in these the following birds were seen: White-throated Sparrow, Canada Jay, Cedar Waxwing, White-winged Crossbill, Red-breasted Nuthatch, Golden-crowned Kinglet, Chickadee, Nashville Warbler and Flicker. All these were found in both swamps with the exception of the Nashville Warbler and Flicker.

There is a marked similarity in the lists of birds seen in each of these five swamps, and five of the species were found in all of them.

4. *Rock Ridge Clearings* (*Station II, 3*).

This habitat consists of all the rock ridges which were crossed by the trail after it left Benson Brook. These ridges were nearly all bare on the top, owing to the absence of soil. They had been burnt over several years ago and the stumps that are left show that they were originally almost if not entirely covered with forests. The trees that were found in places where there was a little soil were almost entirely aspen and birch. The birds found in this habitat were the Cedar Waxwing, Junco, Bay-breasted Warbler, Mourning Warbler, Robin, White-throated Sparrow, Olive-backed Thrush, Sparrow Hawk and Red-eyed Vireo.

Very few birds were seen in the clearings, probably because the heat of the sun drove them to the shade, as most of the birds were observed at the edge of the clearings, in places where the ground was partially covered with trees.

IV. WESTERN END OF ROCK HARBOR AND TRAIL TO SUMNER LAKE.

This station comprised the western end of Rock Harbor and a portion of the adjoining land. It was divided into five habitats.

1. Harbor (Vicinity of Station III, 2).
2. Small Islands (Station III, 1).
3. Bulrush Zone and Delta (Station III, 3).
4. Trail to Sumner Lake (Station III, 4).
   a. Birch Forest.
   b. Birch and Coniferous Forest.
5. Sumner Lake (Station III, 5).

1. The Harbor (Vicinity of Station III, 2).

In this habitat the following list of fish-eating birds were found: Loon, American Merganser, Herring Gull, Kingfisher and Bald Eagle.

An adult American Merganser and a number of young were observed about the middle of July, and about a week later another adult female and twenty-three young were seen. Although the young birds were quite small they were good swimmers, and it was impossible to get near them in a row boat, except by cornering them in a small bay or in the end of the harbor.

The Loon was often seen and heard here, and once seven were seen together. Occasionally one of the flock would swim around and around in a circle as fast as it could, splashing the water so that it could be heard for at least half a mile. It was impossible to get near these birds, not even close enough to shoot them with a shot gun, for as soon as they thought it was dangerous they would dive, to appear after a few minutes very much farther away. It is very difficult for the Loon to rise from the water, as it must fly a long distance flapping its wings and pushing the water with its feet before it can get into the air.

The Eagle was seen on a tree at the edge of the water.

2. Small Islands (Station III, 1).

Near the west end of the harbor there were two small islands partially covered with stunted cedar, spruce and birch trees, where many birds nested. The probable reason for this was that no squirrels inhabited the islands. On one island three or four rods long were found the nests of four Cedar Waxwings, two Myrtle Warblers, a White-throated Sparrow and a Song Sparrow, and on the other island which was somewhat smaller, were a number of Cedar Waxwing's nests, three containing eggs or young, and the remainder being empty, most of them last year's nests. The Waxwing's nests were from three to fifteen feet from the ground and were composed entirely of lichens (*Usnea*). These birds do not get excited as do many birds when their nests are disturbed. When I looked into these nests I did not hear a scolding note, although some of the owners were sitting on a tree not far away.

Four Myrtle Warbler's nests, two old and two new, were found. These nests were placed on spruce and cedar trees, from six to ten feet from the ground, and were composed of small twigs and grasses with a lining of feathers. One nest contained small young, July 21, and the other contained nearly fully fledged young. The White-throated Sparrow's nest was made of small sticks and grasses with a lining composed entirely of grass. It was on some bushes about a foot and a half above the ground, and contained one egg.

3. *Bulrush Zone and Delta (Station III, 3).*

This small grass and sedge covered marsh was too small to attract many marsh birds, and a pair of Swamp Sparrows with two young, a pair of Kingfishers and Song Sparrows, a Red-winged Blackbird and the Lesser Yellow Legs were the only birds observed here. The last two were only observed once, and no doubt they were only stragglers here.

This small marsh was surrounded by a forest of spruce, birch and balsam, and here the Golden-crowned Kinglet, Magnolia Warbler, Chickadee and Red-breasted Nuthatch were found.

4. *Trail to Sumner Lake (Station III, 4).*

Starting from the harbor this trail first went up a hill through a birch forest, then across a narrow cedar swamp into a birch, spruce and balsam forest and down the hill to Sumner Lake. As the birds found in the birch forest were not the same as those found in the birch, spruce and balsam forest, the habitats will be distinguished. The cedar swamp was too small to be of any importance, and the birds in it were nearly the same as in the birch, spruce and balsam forest of which it will be considered a part.

a. Birch Forest.

Judging from what had been observed before these birch woods were visited, I expected to find the Oven Bird and Red-eyed Vireo, and upon investigation, many of both kinds were found. A family of Black-throated Green Warblers were also seen. Several Cedar Waxwings and White-throated Sparrows were observed along the edge of Rock Harbor near the trail, but they occurred almost everywhere along the edge of the Harbor irrespective of the kind of trees. In rowing along the shore these birds were seen very much more often than any other.

b. Birch and Coniferous Forest.

This habitat was frequented by the Chickadee, Golden-crowned Kinglet, and Red-breasted Nuthatch, the three most common birds in all the coniferous forests that were visited. The Winter Wren was heard in the cedar swamp.

5. *Sumner Lake (Station III, 5).*

This habitat included Sumner Lake and the grassy marsh which surrounded it. Everywhere in the marsh the ground was soft, and the thick mat of grass sank under the weight of the body until the water poured into the shoe tops. The line dividing the grass and sedges from the forest was very distinct, but there were several stunted tamaracks and alders growing out in the marsh (*Figs. 18-23*).

Many White-throated Sparrows were heard in the forest near the marsh, and at the foot of one of the alder bushes near the edge a nest was found hidden in a bunch of grass growing around the bush. Here in a well built nest of grass were two nearly fledged young (July 18). On the same day another nest of this bird was found on the other side of the lake, in a position similar to the one described above, but instead

of young it contained four bluish white eggs densely and irregularly variegated with brown. Out in the marsh a Bittern was flushed from the grass, and near by a deserted nest containing a bad egg and the bones of two young was found. This nest was only a depression in the tangled mat of grass in which it was situated.

Two Loons were seen on the Lake many times, and these two birds were much tamer than Loons usually are, for they swam very close to the bank where I was standing. As soon as they saw me one of them gave a weird and rapid "ha! ha! ha!" and on being imitated it would reply every time. A Hooded Merganser, another fish-eating bird, was also observed here.

V. SISKOWIT BAY REGION.

When I arrived here in August the breeding season was practically over. Many young birds could fly almost as well as the adults, and families were roving about the forests. Sandpipers were probably migrating then, and although many were seen here it cannot be said that they bred. In two weeks other birds began to come from the north in large flocks, so that most observations were on habits of birds during migration.

Another evidence that the breeding season was over was the decrease in the amount of singing. This was first noticed on July 20, and in the next few days some species were heard for the last time. The following is a list of birds with the last date upon which they were heard singing: Nashville Warbler, July 24; Myrtle Warbler and Olive-backed Thrush, July 25; Wilson's Thrush, July 26; Magnolia Warbler, Black and White Warbler and Redstart, Aug. 4; Winter Wren, Aug. 8.

Although birds are more apt to be found in all kinds of conditions during migration, yet many of them showed a preference for certain localities, so the localities in which the birds were seen will be given. This station has been subdivided into the following habitats:

1. Siskowit Bay and Shore (Station V, 1).
2. Trail to Siskowit Lake (Station V, 4).
3. Siskowit Lake (Station V, 6 and vicinity).
4. Burning West of Outlet to Siskowit Lake (Station V, vicinity of 9).
5. Long and Menagerie Islands (Station V, 10).

1. Siskowit Bay and Shore (Station V, 1).

The conditions at this place were about the same as those at Rock Harbor, and almost the same species of birds were seen. Those seen here were: Herring Gull, Loon, Scaup Duck, Solitary Sandpiper, Spotted Sandpiper, Kingfisher, American Merganser and Osprey.

I cannot say with any certainty how many of these birds bred in this vicinity, but the Gull and Merganser did, as a female Merganser with a flock of very small young was seen several times, and the Herring Gulls bred on the Islands south of the bay. The Loon, Kingfisher and Spotted Sandpiper were observed nearly every day. The Solitary Sandpiper was seen only once, on August 16.

On August 8 four young Gulls were obtained from a fisherman, and

we had an opportunity to study the habits of these birds. One was nearly full-grown, while the other three were just getting their wing feathers. All were quite tame and the oldest would eat from the hand and allow itself to be picked up. We were surprised to find how clean these young Gulls were, for the nests were as filthy as those of the domestic Pigeon. They all seem very fond of bathing, and the largest one took a bath several times a day. It would swim out into the bay, splash water over itself with its head and wings, dip its head under water, then shake itself; after repeating these performances several times it would come to the shore, flap the wings and jump as if trying to fly. They were very particular about keeping their bills clean, for after eating they would walk to the water, immerse the bill and shake the head.

2. *Trail to Siskowit Lake (Station V, 4).*

This habitat included all the forest along the trail between Siskowit Bay and Siskowit Lake. If it had been in the breeding season it might have been divided into two or three different habitats, but the migrating birds did not seem to show any preference for a particular forest.

The birds seen at this station were as follows: Golden-crowned Kinglet, Chickadee, Raven, Pigeon Hawk, Winter Wren, Red-breasted Nuthatch, Bay-breasted Warbler, Red-eyed Vireo, Hairy Woodpecker, Magnolia Warbler, Black-throated Green Warbler, Brown Creeper, White-throated Sparrow, Tennessee Warbler, Flicker, Canada Jay, Junco, Blue Jay, Pileated Woodpecker, Nashville Warbler, Sparrow Hawk, Chipping Sparrow, Grinnell's Water Thrush, Purple Finch, Pine Grosbeak, Sharp-shinned Hawk, Myrtle Warbler, Black-throated Blue Warbler, Olive-backed Thrush, Downy Woodpecker, Yellow-bellied Flycatcher, and Cape May Warbler.

The nests of only two birds were found here, the Chickadee and Golden-crowned Kinglet. The Chickadee's nest was in a dead birch tree about ten feet from the ground, and contained four young which were able to leave the nest August 11. The Kinglet's nest was in a spruce tree about thirty feet from the ground. Both old birds were observed carrying insects into the tree, but the top was so thick that the nest could not be seen from the ground. On August 16 the young birds were still in the nest.

The Nashville Warbler, Olive-backed Thrush, Junco, White-throated Sparrow and Chipping Sparrow frequented partial clearings or clearings in the breeding season but were found in the forests in the second week in August. On August 11 a flock of birds were seen feeding in the top of a tall tamarack. They were mistaken for warblers but on shooting one to identify it, it was found to be a Chipping Sparrow.

3. *Siskowit Lake (Station V, 6).*

This Lake was six miles long and about two miles wide at the widest part. The shores were mostly rocky, and trees grew down nearly to the waters edge. The birds found here were: Herring Gull, Osprey, Eagle, Spotted Sandpiper, American Merganser, Loon, and Kingfisher.

The Song Sparrow and Grinnel's Water Thrush were also seen along the shore.

The American Merganser, Loon, and Eagle nested in the neighborhood. Three different families of Mergansers were seen on the lake. One consisted of a female and three young, but I did not get close enough to the other two flocks to count them. When first observed, these two flocks were together, but they separated when we rowed toward them. Two young Loons in the down were seen August 10. An Eagle's nest composed of sticks was found about 125 yards north of the lake, on top of a dead pine which was at least sixty feet high. The nest was four feet in diameter, and contained one young bird nearly ready to fly.

4. *Burning West of Outlet to Siskowit Lake* (*Station V, 9*).

Here the original forest had all been burnt away and was only partially replaced by a second growth of birch, mountain ash, aspen, wild cherry, June berry, and northern maple. Between the trees the ground was covered with grass, currants, fire weed and other plants.

The stream that formed the outlet of Siskowit Lake formed the eastern boundary of the burning. The birds found in this partial clearing were as follows: Purple Finch, Cedar Waxwing, Hawk Owl, White-throated Sparrow, Chickadee, Redstart, Myrtle Warbler, Flicker, Red-eyed Vireo, Black and White Warbler, Nashville Warbler, Sharp-tailed Grouse, Water Thrush, Olive-sided Flycatcher, Chipping Sparrow and Song Sparrow.

The Hawk Owl bred some place near here, as a young bird with only down on its head was taken August 4. This owl was seen flying around the clearing in the middle of the day and in the bright sunlight. The young bird was quite tame, or rather it was ignorant of the ways of man. It flew from one dead stub to another uttering a peculiar screech as it flew. The old bird was seen about a quarter of a mile away on the top of a dead tree, but was wary and flew away.

Along the stream there were several dead trees still standing, and on these trees eight to ten or more Myrtle Warblers were seen many times. These warblers sat on the limbs and watched for flies like flycatchers, and every few minutes the snap of a bill sounded the death note of some unfortunate insect. They did not sit in one place as long as a flycatcher does, but on the other hand they were not constantly in motion like most warblers.

Very little can be said about the other birds that were seen here. The Purple Finch and Cedar Waxwing fed on the berries here, and a Grouse was taken with berries and grasshoppers in its crop. The Water Thrush was seen near the lake and stream.

5. *Long and Menagerie Islands* (*Station V, 10*).

These two long narrow rocky islands were on the south side of Siskowit Bay about three miles from the mainland. Long Island was covered with trees except for a wide belt along the shore which was washed clean by the waters. Menagerie Island, on which the lighthouse was situated, had very few trees on it, as the top was barely out of the reach of the waves in severe storms.

Menagerie Island was visited twice, on August 6 and 16. The birds seen here were: Song Sparrow, Barn Swallow, Tree Swallow, Herring Gull, Spotted Sandpiper, and Humming Bird.

The Barn Swallow built in the boat-house and under the cliffs along the shore. On August 16 the nests under the cliffs contained young nearly ready to fly. These cup shaped homes were composed of moss and mud, lined with feathers, and placed on small projections of the rock.

The light-house keeper, Mr. J. A. Malone, told us that the Tree Swallow built in the tower; but at this time the young were probably gone as none were observed entering the light-house, although many were flying around.

Long Island was visited on August 6, but no observations were made on any birds except the Gulls. These birds nested here by the thousands. The nests were among the rocks, some being just beyond the reach of the waves of ordinary storms, and others back among the bushes. They were from one to two inches thick, and composed of grasses, sticks or moss, depending on which of these materials was found near. Most of the nests were on the south side of the island, and only a few were found on the north shore. At the approach of the boat the young Gulls that could not fly swam out into the water or hid in the bushes, while the old birds flew around overhead uttering their weird notes of alarm.

XI. Summary.

This brief review of the birds found in each of the habitats studied on Isle Royale will give an idea of the birds that should be expected to occur in similar habitats of the island which were not visited. Of course only the common birds will be mentioned, because preference cannot be determined by a few observations. The habitats of this rugged and hilly island presented a variety of conditions. There were bays, lakes and harbors, with rocky shores, wave-beaten and desolate. There were swamps that were covered with sphagnum moss and low bushes with here and there a black spruce or tamarack tree, other swamps that were covered with a dense forest of cedar and tamarack. There were clearings and partial clearings, forests of birch, containing scattered balsams and spruce, and still other forests of spruce and balsam containing a few birch trees. The characteristic birds of each of these habitats will be discussed in the order just given.

1. *Water Birds.* The water birds found on the harbors and small lakes were the Herring Gull, Loon, American Merganser, and Hooded Merganser. Of these birds the Herring Gull was the most abundant species and could always be seen on Lake Superior and quite often on the smaller lakes on the island. The American Merganser probably ranked second in abundance. The Loon was quite numerous, and at first it seemed as if they were more abundant that the Merganser, but in time it became evident that the Merganser was the more numerous, though much less conspicuous, as they did not make any noise, while the Loon is very noisy and can often be heard a mile away. The Merganser frequented the bays, harbors and larger inland lakes. The Loon was seen very often on the larger bodies of water, but seemed to

prefer the smaller lakes more than the other water birds, as every little lake contained a pair of Loons. Young Mergansers and Gulls were often seen, but, strange as it may appear, young Loons were only seen once, August 10.

The Osprey, Eagle and Kingfisher were also seen several times, but only the latter was seen around any of the smaller lakes, and it was not often seen. These lakes abounded in small fish and would have been a good feeding ground for Kingfishers, but there were no sand banks around the small lakes where it could have nested, and this may have been the reason for its absence. There were two sand banks along the shores of Rock Harbor, and these were used as nesting sites.

2. *Shore Birds.* The Solitary and Spotted Sandpipers were seen along the shore, but these were probably migrants as only one or two Spotted Sandpipers were seen before August 1.

Although they were not shore birds the Cedar Waxwing, Winter Wren and White-throated Sparrows were often seen and heard while rowing along the shore. The Cedar Waxwing would sit on the tops of the dead trees and every few minutes would fly out over the water after insects.

Herring Gulls nested on the shores of the smaller islands in large numbers but very few nested on the main island. There is a reason why they choose the smaller islands instead of the mainland, and it is probably because there are no minks, lynx or other carnivors on these small islands. The Gull seems to place its nest on the shore at random, without any view to protection or secrecy, and if there were mink or lynx about the young would soon all be killed by these animals.

The Barn Swallow nested underneath the cliffs along the shore at Menagerie Island and at Scovill Point. The Song Sparrow and Myrtle Warbler were often seen feeding on the shore, and both were found breeding near it. The Song Sparrow frequented the small rocky islands in front of the light-house, one of the islands in the west end of Rock Harbor, and also Ransom Clearing on the north side of the Harbor. Even in this clearing it was never seen far from the water. The Myrtle Warbler was found breeding on the north shore of Tonkin Bay, and on an island in the west end of Rock Harbor.

3. *Birds Frequenting Swamps.* The characteristic birds of the tamarack-spruce swamps were the Cedar Waxwing, Chickadee, Red-breasted Nuthatch, Golden-crowned Kinglet, White-winged Crossbill, Canada Jay, Nashville Warbler and White-throated Sparrow. Probably none of these birds were found here simply because it was a swamp, for all frequented other localities. The White-throated Sparrow, Cedar Waxwing, and Nashville Warbler are characteristic of partial clearings, and this was really a partial clearing because the trees were so far apart. The White-winged Crossbill, Red-breasted Nuthatch and Golden-crowned Kinglet are characteristic of coniferous forests, and as the trees in the swamp were nearly all coniferous trees, this would therefore be their natural habitat. The White-winged Crossbill feeds on the seeds of the tamarack trees, and during the first few weeks of July it was only seen where there were tamarack trees; during the latter part of July, when the seeds of the spruce became more mature, they were seen many times in the spruce and balsam forests.

The seeds of the tamarack mature quicker than the spruce, hence the Crossbills would prefer the tamaracks during the earlier part of the summer. The Black-throated Green Warbler was characteristic of forests where there were a number of large birch trees, and this bird was only seen in those swamps which had several of these trees around the edge. Indeed the only true swamp bird seen here was the Marsh Hawk, and that was only seen once.

In the thickest part of the cedar swamp only a few birds were seen, and these were the Winter Wren, Chickadee, Red-breasted Nuthatch, and Brown Creeper. The Canada Jay, Nashville Warbler, Black-throated Blue Warbler and Black-throated Green Warbler were seen where the trees were tall and farther apart.

4. *Birds of Clearings and Partial Clearings.* The characteristic birds of the clearings were the Chipping Sparrow, Junco, White-throated Sparrow, Flicker, Cedar Waxwing, Purple Finch and Sharp-tailed Grouse:

The Cedar Waxwing and Purple Finch were often seen feeding on berries in the clearings, and a Flicker was observed scratching in an ant's nest and eating the ants. Many ants nests were found scratched to pieces, probably by these birds.

The characteristic birds of the partial clearings were the White-throated Sparrow, Cedar Waxwing, Chickadee, Olive-backed Thrush, Wilson's Thrush and Nashville Warbler.

5. *Birds Frequenting the Forests.* In the forests of birch or aspen the Red-eyed Vireo and Oven Bird were quite abundant, and in many small tracts of birch and aspens these were the only birds seen. Other birds seen many times in these forests were Wilson's Thrush, Chickadee, Black-throated Green Warbler and Canada Jay. The characteristic birds of the spruce and balsam forests were the Chickadee, Red-breasted Nuthatch, Golden-crowned Kinglet, Magnolia Warbler, Canada Jay and Wilson's Thrush. The Magnolia Warbler seemed to prefer places where the trees were not very high, for on the small rocky knolls which were covered with stunted spruce and balsam, this bird was more numerous than elsewhere.

THE FALL MIGRATION OF BIRDS AT WASHINGTON HARBOR, ISLE ROYALE, IN 1905.

BY MAX MINOR PEET.

I. INTRODUCTION.

Our observations of the fall migrations of birds at Washington Harbor extended over the period from August 18 to September 22. A hasty examination was made of the bird life here before migration had really set in (August 5 to 8), and the observations gathered at this time, together with the records obtained the previous year, gave us an insight into the conditions existing there. This was important, as migration had commenced while we were still at Siskowit Bay.

Isle Royale is situated about fifteen miles from the north shore of Lake Superior, and lies nearly northeast by southwest. Situated as it is several miles from the north shore and with an unbroken stretch of water 100 miles across lying south of it, the island makes an excellent point for the migrants to stop before crossing the lake. The birds seemed to center at Washington Harbor as if focussed there from the north shore, and in all probability the birds observed there represented the avian life of many square miles on the mainland. Records were kept of the species seen each day and are given in tabulated form at the end of this paper.

II. THE ENVIRONMENT.

1. *The Clearing.* Under the head of clearings, we include the three artificial clearings and the narrow roads connecting them. The first of these was situated on the shore of Washington Harbor, near its head and close to the mouth of Washington River. The trees had been entirely cleared away over an area of several acres, making a rectangular clearing which had been seeded to timothy and short grasses. The waves had cut away the soil along the shore leaving a nearly vertical bank two or three feet high, in some places overhanging the water. The land gradually rises from the water's edge, more rapidly at the southern end where a low bluff is formed. On this bluff the Club-house stands, and below, nearer the lake, is a little group of four small houses, the largest of which we used as a camp. Other buildings were also located in this clearing. Part of the clearing was overgrown with brush and small trees. These had been burned and the debris left where it fell. Many small bushes, weeds, and vines sprang up among the fallen logs and branches, forming on ideal retreat for the smaller birds such as warblers and sparrows. The rank growth of the vegetation made it almost impossible to penetrate any distance into it. Here the Lincoln Sparrows were most abundant during their migration. As the soil was very shallow, the timothy grew short and scattering, and probably furnished little protection for the birds, as it was cut

about the middle of August. Near the road leading to the second clearing to the north was a small spot cleared for a garden. This bare ground was the favorite feeding place of the Horned Larks. On the short, steep slope which skirted the road to the second clearing, thirty or forty stumps had been left. These were the favorite perches for the Sparrow and Sharp-shinned Hawks, and the tops of many of them were covered with the harder portions of grasshoppers, these insects forming one of the principal foods of these birds. Three narrow roads or trails left this clearing, one to the second clearing, one to the head of Siskowit Bay, and the third to Lake Desor. The first of these was kept open and had originally been much wider than at present, being narrowed by a fringe of alders, birches, and small bushes together with young balsams and spruces.

The second clearing, consisting of 3 acres, was divided into two parts, a grassy tract and a garden in which potatoes, carrots, etc., were grown. From this a road (*Fig. 56*) led to the third clearing, called Wendigo, which was about the same size, and contained two old log houses and two or three decaying sheds. Few of the stumps had been removed and hawks used them as perches. The ground was overgrown with short, nearly dead grass. White-footed mice were abundant in these clearings after nightfall, and many Northern Hares were seen along the roads just at dusk. A narrow road wound past the clearing and off along the base of the bluffs for a mile or more to several abandoned cuts made by the old mining company. It was along these roads, which ran approximately north-east and south-west, that the bulk of the migrants passed. Even during the heavy migration comparatively few birds were observed in the dense forests, although many passed along the river. It has been generally noticed that many birds, the smaller migrants in particular, as the sparrows and warblers, prefer the borders of clearings, and a long narrow road through heavy timber and bordered by bushes and small trees, appeared to be an ideal place for them. All the clearings were surrounded by the dense, coniferous forest except the first which fronted on the lake.

2. *The Forest.* The forest may be considered to consist of all that portion which has not been entirely cleared of the native trees. The major part consists of balsam and spruce with a heavy undergrowth of ground hemlock, and in places along the river there are dense thickets of alder. The soil in the depressions is damp, with small pools of water standing on the decayed leaves. Washington River flows through the lower portion of the forest. It is a stream sixty or seventy feet wide near its mouth, but it rapidly diminishes in size, so that near Wendigo is not more than five or six feet across. However it becomes much more rapid and the banks are covered with refuse and fallen logs and branches.

Few resident birds were found in the dense, dark forest, and still fewer migrants were found there. During very severe weather the Chipping Sparrow sometimes retreated to the protection of the balsams, but it never wandered far from the open. The White-throated Sparrow was quite common, breeding in the forest along the river, and even during migration it was found most abundant in the underbrush. The

Sharp-shinned and Sparrow Hawks rarely remained here, except during the night, or in very stormy weather. The warblers were scarcely ever found in the heavy timber, but along the more open part of the river and in the alder thickets they were abundant. By far the most common warbler along the river was Grinnell's Water Thrush. This bird was confined almost entirely to the forest, and especially to that portion bordering the stream where fallen logs and rubbish furnished their favorite haunt. They seemed to be migrating in pairs, but no immature birds were seen with them. During the stormy period lasting from September 2 to 5, the Water Thrush came out into the road and clearings. The Wilson and Olive-backed Thrushes bred in the forest, but during migration they preferred the open and were only occasionally found in the heavy timber. The path skirting the river was also a favorite route for them. The maple brush which bordered the forest in many places was the favorite habitat of the Hermit Thrush. This and the diminutive Winter Wren were sometimes met with among the very densest conifers. Among the other birds occurring here were the Brown Creeper, Golden-crowned Kinglet, and Red-breasted Nuthatch. Chickadees were nearly always present. This habitat was chosen by nearly all of these birds during migration, probably because it furnished the right kind of food and excellent protection. Many other species were occasionally met with, but they were only wanderers and no particular significance can be attributed to their occurrence here.

3. *Food.* The clearing afforded abundant food for nearly all species. The grassy meadows and dry hillsides were infested with great swarms of grasshoppers which rose up before one as a buzzing cloud. Nearly all the birds taken, among which might be mentioned the Sharp-shinned and Sparrow Hawks, Thick-billed Redwing, Rusty Grackle, Flicker and Nighthawk, fed to a greater or less extent on these pests, as was shown by an examination of their stomachs. Many other species of insects were abundant; blackflies, deer flies, and "no-see-ums" being at times almost unbearable. The Deer Mouse was very plentiful, and also the Northern Hare, as many as twenty or thirty of the latter being seen at one time feeding in the road between the first and second clearings. These animals together with the large number of Red Squirrels found along the edge of the road furnished abundant food for the owls and migrating hawks. Seeds were plentiful and constituted the principal food of the Savannah and other sparrows. Wild red raspberry bushes were common and these berries together with several other kinds were greedily eaten by many of the birds, especially the Cedar Waxwings. A few wild flowers grew in the clearing and these were occasionally visited by the Ruby-throated Humming Bird. Insect life characteristic of coniferous forests was probably abundant because the Brown Creeper, Chickadee, and Golden-crowned Kinglet fed here almost exclusively; otherwise this habitat did not appear to furnish much food for the migrants.

III. THE WEATHER CONDITIONS AND MIGRANTS.

1. *Weather Conditions.* Throughout the period of thirty-five days during which observations were made on migration at Washington Har-

bor, a daily record was kept of the direction of the wind, temperature, and the general weather conditions. The barometric readings, taken at Port Arthur, thirty-five miles nearly due north from the Harbor, are from the daily weather maps. A comparison of my observations on the weather with those from Port Arthur shows that the conditions at the two places were much the same, so I feel safe in assuming the barometric pressure at the island to be approximately that recorded just to the north. An examination of the daily weather maps for this period shows that the same isotherms and isobars include both localities. Unfortunately Port Arthur is the most northern station on the daily weather map that could have any appreciable effect on the bird life of Isle Royale. A reference to the areas of high and low pressure indicates that conditions similar to those on the island probably prevailed over a large area to the north of it.

The records for the entire thirty-five days are included in the following table. The readings were made between 7:30 and 8 A. M. Other readings were made during the day and where these are of importance I will give them under the particular discussion upon which they bear. All temperature readings were in Fahrenheit. The dates of the large bird waves are starred.

TABLE.

Date.		Barometer.	Temperature, F.	Wind.	Sky.
Aug.	18	29.7	62	S.	Rainy.
	19	29.7	55	W.	Clear.
	20	29.7	58	S. W.	Partly cloudy.
	21	29.6	62	S. W.	Cloudy.
	22	29.9	52	W.	Clear.
	23*	29.9	58	N. W.	Clear.
	24*	30.2	53	N. W.	Clear.
	25*	30.3	50	None.	Clear.
	26*	30.2	54	None.	Cloudy.
	27	30.1	53	None.	Clear.
	28	30.1	56	S. W.	Clear.
	29	29.9	61	N E.	Rain.
	30*	29.8	56	N. W.	Clear.
	31*	30.1	46	N.	Clear.
Sept.	1*	30.1	52	N. E.	Cloudy.
	2	30	44	N. E.	Hard rain.
	3	....	40	N. E.	Hard rain.
	4	....	44	N. W.	Clear.
	5*	30.1	39	N. W.	Partly cloudy.
	6*	30.1	42	N. W.	Clear.
	7	30.1	45	None	Rainy.
	8	30.2	52	S. W.	
	9	30.1	45	N. W.	
	10	30	52	N. W.	
	11	29.8	52	N.	Clear.
	12*	30.2	42	N. W.	Clear.
	13*	30.4	26	W.	Clear.
	14	30.2	47	S. E.	Rain.
	15	29.8	52	None	Clear.
	16*	30	50	E.	Cloudy.
	17	29.9	53	N. E.	Clear.
	18*	29.8	52	N. E.	Clear.
	19	29.4	59	N. W.	Cloudy.
	20	29.8	46	W.	Clear.
	21	29.5	54	W.	Clear.

*Large bird waves.

2. *The Bird Migrants.* a. *Warblers.* Many warblers nest on the island, and so the first indication of migration in this family was the tendency to flock preparatory to the trip south. At first these flocks

consisted only of the parent birds and young, but as these wandered about they were joined by other families and, impelled by the gregarious instinct which is so strong after the breeding season, kept together and formed one large flock. Beginning to feel the migratory impulse they were restless and wandered about over considerable territory, probably being joined from time to time by other families and often by other forms, for a flock of migrating warblers is rarely composed of a single species, as are the flocks of so many birds. Small bands of Myrtle Warblers were seen feeding in the balsam trees on August 18, and on August 19 the first flocks of Tennessee Warblers appeared. However, these were scattered and composed of only a few birds, mostly adults. On August 20 I saw the first Redstarts, and from then on different species were constantly making their appearance. On the 26 the bulk of the Black Poll Warblers began to arrive, only a few adults being seen among the hundreds which came to the clearing. It is a significant fact that, in all cases where the young were not in company with the adults, the latter and not the former, as some have reported, preceded. In the case of the Tennessee Warblers three days elapsed before there was any noticeable number of young, while toward the last of the migration the young greatly outnumbered the adults. Throughout the entire migration, however, the immature Blackpolls outnumbered the old birds, in fact the latter were very rarely seen. Only two Black and White Warblers were observed, and only four small flocks of Black-throated Green Warblers.

The principal feeding grounds were among the alders, birches and balsams which lined the more open parts of the road. In the narrow strips where the high conifers bordered the path, the bird life was scanty, and when these portions were encountered by the migrating warblers they were quickly passed, often in a single flight. The Myrtle Warblers were the only ones observed to linger among these large trees.

The food of the warblers consisted largely of insects, most of it being gleaned from the leaves and twigs of the bushes, but some was taken on the wing. The open area here afforded a greater supply of insects than the forest, and this may possibly have played a part in the choice of this particular habitat.

On cold mornings, when the thermometer registered about 45° F. or below, the warblers would remain hidden in the dense underbrush, not appearing until about nine o'clock, when the sun would be quite warm and the usual morning fog be dispelled. This fog hung over the harbor nearly every morning and frequently was so dense that Beaver Island, in the harbor, was almost invisible. It was often blown back over the clearings, and until it raised, the majority of the birds remained quiet. The height of the migrating movement seemed to be from the middle of the afternoon until nightfall; how far into the night it extended I was unable to ascertain, but the cries of innumerable birds could be heard until nearly morning. These cries, usually of a single faint syllable, were possibly uttered to help keep the birds together. When the migrating flock had to cross the clearing it was a noticeable fact that they rarely flew directly across, thus exposing themselves to the attack of the numerous hawks, but instead kept near to the ground, making short flights from bush to bush, and where these were scattered

they alighted directly on the ground. This was especially noticeable in the case of the Palm Warblers, which often lingered to feed in the grass.

The Sparrow and Sharp-shinned Hawks were the principal enemies of these birds, devouring many each day. During the large bird wave of September 12, the Pigeon Hawk also played a conspicuous part in their destruction. The influence of the hawks will be taken up under the discussion of that family.

During the first days of migration the warblers moved along very leisurely, the same flocks apparently remaining about the clearings all day, but toward the latter part of the season the birds hurried forward, taking their food as they moved along. There were several warbler waves or periods of great abundance, the first occurring on August 23. This one was made up almost entirely of Tennessee Warblers, adult and young being about equal in number. For the remainder of the migration, however, the young outnumbered the adults. The second, made up largely of immature Blackpolls, arrived on August 26. The third wave, consisting principally of Palm Warblers, occurred on August 30. The last wave, and by far the largest, occurred September 12. At this time the clearings and roads were full of warblers, nearly every species observed at Isle Royale being represented to a greater or less extent. These waves will be dealt with separately.

During the heavy rain and wind storms of September 1, 2 and 3, the warbler migration was at a standstill, the birds keeping under cover as much as possible. The Blackpolls and Palm Warblers were the only species which seemed to be unaffected by the weather. These beautiful warblers were observed feeding in the open clearing during the heaviest rains, but even they did not undertake to migrate against the strong wind, so far as I could determine.

b. *Sparrows.* The sparrow migration began much later in 1905 than in 1904, some of the most striking examples being Savannah, Aug. 17, White-crowned, Aug. 28 and Lincoln, Sept. 1, 1904. On August 18, (1905) the first day observations were made, Chipping and White-throated Sparrows were seen, The Chipping had gathered into flocks and roamed about the clearings, feeding near the borders, while the White-throated were still in single families hunting about among the dead leaves in the damp underbrush. Many of the White-throated Sparrows were still too young to migrate, some having a little of the first down on them. On August 22, an immature Vesper Sparrow was taken, the only one found on the island. A few Song Sparrows were present from August 21 to 24. These were the only ones seen and were probably migrating at that time. The next few days the number of both Chipping and White-throated Sparrows was materially increased, large numbers of young of both species making their appearance. Very few of these had moulted the first plumage. Not until August 31 were any other species seen, then large flocks of Savannah Sparrows, both young and adults, came to the clearings. All were in perfect fall plumage. It seems peculiar that none of these birds were seen before this date, because between August 5 and 8, I saw several, and obtained one immature barely able to leave the nest. The food was obtained along the roads, in the meadows, and about the houses, where several lost their lives by entering deserted rooms and not being able to find their

way out. The Sharp-shinned Hawks proved to be their worst enemy. The first flocks of Savannah Sparrows to arrive remained for several days, their numbers constantly increasing. On September 5 many of the Chipping, White-throated, and Savannah Sparrows left the island, and for the next two days only a comparatively few were seen, then others came in from the north and the flocks were rapidly increased.

It was noticeable that most of the birds which migrated from the island on September 5 were adults, the young remaining until a later time. The Savannahs showed the least fear of man during migration of any of the sparrows. On September 12, with the great bird wave, came the Lincoln Sparrows. Throughout this and the next three days hundreds of these birds were seen. As a rule they kept secreted in the burned brush and weeds of the first clearing, but individuals were met with all along the road, where they were seen hunting among the fallen logs and underbrush for insects.

Chipping Sparrows remained throughout the entire period during which observations were made, but probably none of the individuals first seen remained throughout that time. This seems the more likely as on several dates the bulk of the sparrows of all species left, while more came in later from the north.

c. *Hawks.* During a few days spent at Washington Harbor early in August (Aug. 5 to 8) only a few Sparrow and Sharp-shinned Hawks were seen, but by August 18, many individuals of both species had arrived. These remained here to feed on the swarms of grasshoppers infecting the meadows, and on the small birds, as warblers and sparrows, which were easily caught in the exposed clearing. The first few days the Sparrow Hawks outnumbered the Sharp-shinned about 10 to 1, but as the season advanced their numbers became more equal and toward the last the Sharp-shinned outnumbered the Sparrow Hawks, both because of a steady increase of the former and because many of the latter left the island for the south. When the observations were first made the adult Sparrow Hawks were as numerous as the immature, but toward the last of September the adults had nearly all left and many more immature had taken their places. Some idea of their number may be gained from the statement that more than thirty were counted at one time, sailing over the first clearing. Until the middle of September the immature Sharp-shinned greatly outnumbered the adults. These immature were full size, but did not have the spotted plumage of the adult. The females of both species greatly predominated. Toward the end of September many male Sharp-shinned, both immature and adult, appeared. These two species of hawks fed on grasshoppers to a considerable extent, but many crops of both species were found filled with the remains of Tennessee, Palm and Blackpoll Warblers, Savannah Sparrows and other species not determined. As a rule the older hawks were the ones which destroyed the birds, and this may account for their migration from the island at the same time that the large warbler and sparrow wave passed, while the immature hawks remained. Pigeon Hawks were recorded from time to time, but not until September 12, when the lower end of the island was suddenly flooded with bird life, did they appear in any numbers. On this date several flocks of 6 or 8 were seen in different parts of the clearing.

They were preying principally on the sparrows, and were creating great havoc among them. Coming with the great wave they remained throughout the day and passed on with it that night, only one being seen the next morning.

The migration of the hawks is thus seen to have been intimately connected with the migration of the smaller birds upon which they preyed, and seems to give at least one instance of bird migration being influenced by the food supply.

During cold, rainy mornings the hawks rarely appeared in the open, usually not until about 9 o'clock. This, however, was the time the warblers appeared on such days, and this may also have determined their appearance.

d. *Owls.* Only two species, the Great Horned and Acadian Owls. were seen. These were residents at this time and only concerned migration in that they sometimes preyed upon the migrants. Their effect was probably slight.

e. *Thrushes.* Six species were observed migrating, the Bluebird, Robin, Wilson's, Olive-backed, Gray-cheeked and Hermit Thrushes. A pair of Blue Birds nested in a dead Birch at Wendigo, and this family left the island about August 22. On the 24th a small flock probably consisting of two families appeared at the first clearing and remained about the tangled brush until August 31, when they also left. No others were seen except on September 11 and 12. Robins were seen twice during August, but on September 6, the first real migratory movement was initiated, and from then on the number rapidly increased. Small flocks numbering a dozen or so wandered about the clearings and open woodland. Many disappeared on the night of September 12, but the number was soon replenished, and at the time the observations were closed the Robins were quite abundant.

The most common of the Thrushes was the Wilson's. They bred on the island and showed no indications of the migrating spirit until the latter part of August, when they gradually increased in numbers and moved about to a greater extent. After September 6 they became rather scarce, and none were seen after the 14th. Their place was taken by the Olive-backed, and later the Gray-cheeked became abundant. Many immature Olive-backed were seen but this species had nearly disappeared when the great flocks of Gray-cheeked arrived on September 12. They showed little fear and did not seem to be frightened at the report of a gun. The flocks of the Gray-cheeked were made up of immature and adult birds, all in perfect fall plumage.

f. *Other Birds.* Following the breeding season the woodpeckers wander about the island making what might be called a local migration. Perhaps some of these birds leave the island in the fall and probably others come in from the north. In one instance, that of the Flicker, their numbers are enormously increased during the latter part of August and all through September. It is very improbable that any of these latter birds winter on the island. Flickers were seen every day, but the number greatly increased toward the last of September, and from the report of residents the number continues to increase until late October when they appear to leave the island. Many were found dead without any apparent cause, and it was reported that in the latter

part of October hundreds were found dead each year. The Downy and Hairy Woodpeckers visited the clearings occasionally, as did the Pileated Woodpecker.

Several pairs of Kingfishers frequented the river banks, and one pair nested in a sand bank, rearing 7 young. These birds gradually disappeared, until on September 15 the last ones left. Families of Redbreasted Nuthatches occasionally visited the clearings, often accompanied by Chickadees. During August, Crows were commonly seen, but by the latter part of September they had entirely disappeared, whether to the south or not it was impossible to determine. Several species of flycatchers and vireos were seen migrating, the Alder, Green-crested, and Least Flycatchers being seen several times, while only one Yellow-bellied was found. Both young and adults of the Least Flycatcher were seen, usually together.

One pair of Chimney Swifts was observed circling over the river on August 19. Whether these were migrating I do not know, but they were the only ones noted here in 1905. One of the most conspicuous species during August was the Thick-billed Redwing Blackbird which came to the clearing in flocks numbering from about 30 to 50. Flocks composed of young and adults arrived nearly every day. The proportion between the two seemed to be about equal, or if anything, in favor of the adults. None were in the black breeding dress, and only a few males had the red on the shoulders out of the pin feather stage. The majority left on August 26, a few were seen on August 29, 31, and September 2, and two young were found on the 8th, 9th and 10th. A single specimen was taken September 16 and another, partially moulted, on the 20th.

There were many instances where only an individual or a single flock of a certain species was seen. Among these might be mentioned the Catbird observed on September 12, which was the only one the expedition noted either in the Porcupine Mountains or Isle Royale during both years, the Philadelphia Vireo, Blue-headed Vireo, Chimney Swift, Vesper Sparrow, Humming Bird, Migrant Shrike, Black-throated Blue Warbler, Black-throated Green and Black and White Warblers, Yellow-bellied Flycatcher, Red-eyed Vireo, and Kingbird. Of these, only two of the Philadelphia Vireo and Chimney Swift were seen, and but single individuals of the Migrant Shrike, Black and White Warbler and Ruby-throated Humming Bird.

IV. LARGE BIRD WAVES.

During the period from August 18 to September 21, six large bird waves passed over the island. Sometimes the waves were composed principally of one species, and again several species occurred in varying numbers. These bird waves were mostly from the north, although small ones, consisting of the birds which had accumulated on the island, took place at various times.

A bird wave may be recognized, first, by a sudden increase of individuals, second, an increase of species, or, third, by a sudden decrease in the number of birds which were residents or had gradually accumulated on the island. During the large wave of September 12, all of

these evidences were present, but usually only one or two were recognized, the most pronounced of which was the great increase of birds as they passed along the roads from one clearing to another.

In some cases the bird wave marked the date of first arrival, at other times it simply marked the arrival of the bulk. The bird waves were generally sharply defined, so that their relation to the atmospheric changes could be noted to the best advantage. The bulk of the migration took place during the nights of bird waves, although there was a constant going and coming of certain species throughout the fall. Being almost constantly in the field the writer had excellent opportunities to study the migration when it was most pronounced, that is, during the large waves.

1. *First Wave.* The first wave observed occurred on August 23, and consisted principally of Tennessee Warblers, immature and adults being about equal in number. At 7:00 A. M., the temperature was 58°, a rise of 6° in the last twenty-four hours. The weather was clear, and it was in fact one of the most beautiful autumn days of the season. A light northwest wind prevailed, the barometer standing at 29.9 inches (low). This wave lasted for three days. The day previous the weather conditions had been about the same, except that the thermometer stood at 52°. An area of low pressure (29.75) was advancing towards the island and on this date was central over Assiniboia. On the 23d this area was central over Isle Royale and the area to the north and northeast of it. On August 24 a low area was centered over northeastern Missouri while the high pressure which followed it reached very nearly to Isle Royale, thus lowering the temperature to 53° with a northwest wind and barometer reading of 30.2. On the 25th of August the high (30.3 inches) included the island and the area directly south of it. The weather was clear, no wind, and a fall in temperature to 50°. On this date the beginning of the large wave of Blackpoll Warblers commenced, many large flocks appearing before nightfall. On the fourth day of the wave (August 26) the barometer fell to 30.2 with an increase to 54° in temperature. There was scarcely a breeze, and the day was for the most part humid and cloudy. The bulk of the Blackpolls arrived during the previous night and throughout the day. The wave lasted for several days, decreasing gradually in volume, so that it was difficult to tell exactly when it stopped, if in fact it did not grade off into the next one.

2. *Second Wave.* On August 30 great flocks of Palm Warblers invaded the island. On the previous day the area of low pressure was central over the region a little to the west of Isle Royale, with a barometric pressure of 29.9, a temperature of 61°, and wind northeast with rain. On the 30th the low area had passed on to the St. Lawrence Valley and the advancing high pressure was over Manitoba. The barometer stood at 29.8 with a northwest wind blowing 4 miles per hour and a temperature of 56°. This wave also lasted three days and might have continued longer but for the severe gales which set in on the night of September 1.

The second day of this wave (August 31) the area of high pressure (30.1) was central over all of Northern Michigan, a considerable area north of it, and south to southern Wisconsin. With the high pressure came a drop in temperature to 46°. The day was clear with a north

wind blowing about 4 miles per hour. The Palm Warblers continued to come in large flocks and were by far the most abundant bird at the Harbor. The vanguard of the migrating host of Savannah Sparrows appeared early on the morning of the 31st, and by evening the clearing was fairly covered with them; more came during that night and all the next day large flocks were arriving at the first clearing. There was no appreciable increase during the four succeeding days among the bird migrants. The third day of the wave (September 1) the barometer stood 30.1 inches, temperature 52°, with a northeast wind and a cloudy sky. This day marked the close of this wave both of birds coming to and leaving the island. This wave might have been checked either by the gales which followed or the change of the wind from north to northeast. A few birds attempted to cross during these succeeding days, as many were killed by striking the lighted windows, etc., or were found in an exhausted condition. These were probably part of that steady stream of migrants which continues to pass south during the fall, without any marked wave and in general disregard of the weather conditions.

3. *Third Wave.* This wave was noticed first on September 5 when the bulk of the Chipping, White-throated, and Savannah Sparrows left the island, and on September 6 the first real migration of the Robin commenced. I have considered these two days as parts of one wave, controlled by the same conditions, for probably the same influences acting at the same time caused the sparrows to leave the island and the Robins to leave their more northern home. The weather conditions were such as seem to be most favorable for fall migration. On September 5 the high pressure had advanced to an area lying from Winnipeg on the north to Memphis on the south, and extending east nearly to Duluth. The barometer stood at 30.1 (high) with a northwest wind blowing six miles per hour and a temperature of 39°. The day was partially cloudy, but no rain fell. On the 6th an area of high pressure had formed over the region directly to the north and northeast of the island. A moderate northwest wind prevailed with the barometer at 30.1 inches, and thermometer 42°, and the weather was clear. A few Robins had been noted before this, but these were only scattered individuals or pairs, but on this date a large number came to the island, both young and adults being seen, although the latter greatly predominated.

4. *Fourth Wave.* On September 12 the largest wave of the season occurred. For number of species as well as individuals it could scarcely be compared to the other large waves, a total of 41 species being observed in actual migration on this day. On the previous day the low area was central over Lake Erie, and a similar area was formed over the Dakotas. The barometer stood at 29.8 inches, the temperature at 52°, with a north wind and a clear sky. It was cloudy, however, on the north shore. On the morning of the 12th the low area was central over New England, while the western one had moved south and had been followed by an area of high pressure central over the Dakotas and Western Minnesota. The island lay between the isobars of 30.1 and 30.2 inches, with a temperature of 42°, and a northwest wind averaging 8 miles per hour. The day was clear and seemed perfect in every way. The birds were so plentiful in the clearing at 6:30 A. M., as to attract my attention from the windows. Unlike the other bird waves, the

motion was continuous, scarcely a break occurring in the steady stream of migrants as they passed along the road. There was very little lingering by the way, although when the birds arrived at the first clearing they often scattered about, feeding on the myriads of insects infesting the grass and shrubbery. Many of the birds after collecting into great flocks, sometimes numbering more than a hundred, rose directly from the clearing and taking a southwesterly direction, left the island, presumably for the south shore. As a rule the birds flew directly down the Harbor and the fishermen and tourists at Washington Island reported that never before had they seen such numbers of birds except during the spring migration. These observers reported that the majority of the flocks passed at a considerable height above the island, many of them probably belonging to the same flocks that left the clearing four and one-half miles up the bay. Some species, particularly the warblers and sparrows, flew from the ground in practically the direction they took when on their way, but others as the American Pipit, Rusty Grackle, Horned Lark and Thick-billed Redwing flew around in great circles, often hanging around the border of the clearing for some time, as if not quite decided whether to go or not. No flocks of the last named bird were seen on this day, however. As I passed up the road toward Wendigo that morning I met flock after flock of Palm Warblers, Grey-cheeked Thrushes, and Savannah Sparrows. The progressive movement of the migratory birds was clearly shown as they passed in a southwesterly direction along the road from Wendigo to the clearing at the Club House.

Darting everywhere were Sharp-shinned and Sparrow Hawks, while every few minutes a Pigeon Hawk would dash by. All the birds seemed restless as if impelled by some uncontrollable spirit to keep ever on the move. Warblers, thrushes, sparrows and flycatchers were constantly crossing and recrossing the path in front of me.

During the night of September 12 nearly all the birds left the island. Towards evening the temperature gradually dropped, until at 9 P. M. it was only 38°. The morning of the 13th was one of the coldest I experienced on the island, ice remaining on the water pail until nearly noon. During the night the area of high pressure had advanced until at 7:00 A. M. it was central over Isle Royale with a barometer reading of 30.4, temperature at 26°, and a brisk west wind. The sky was clear, as is usual under high barometric pressure. Many Lincoln Sparrows remained, as well as numerous flocks of Gray-cheeked Thrushes. But the great flood of migrants had passed on the previous night. However, the wave set up by these very favorable conditions was not yet over. Large flocks of Horned Larks numbering from about 60 to 200 or more came to the clearing, feeding on the insects and seeds in the open meadow and on the cultivated ground. On this morning many dead birds were found, among which was an adult male Yellow-bellied Flycatcher, the only one of this species seen.

The following is a list of the 41 migrants which composed this remarkable wave of September 12: Chipping Sparrow, White-throated Sparrow, Sharp-shinned Hawk, Sparrow Hawk, Blue Bird, Flicker, Myrtle Warbler, Tennessee Warbler, Phoebe, Redstart, Least Flycatcher, Hermit Thrush, Spotted Sandpiper, Pigeon Hawk, Robin, Olive-backed Thrush, Golden-crowned Kinglet, Cooper's Hawk, Wilson's

Thrush, Solitary Sandpiper, Magnolia Warbler, Palm Warbler, Ovenbird, Bay-breasted Warbler, Blue Headed Vireo, Blackpoll Warbler, Savannah Sparrow, Black-throated Green Warbler, Grinnell's Water Thrush, Marsh Hawk, Catbird, Black-throated Blue Warbler, Nashville Warbler, Philadelphia Vireo, Red-eyed Vireo, Lincoln's Sparrow, Connecticut Warbler, Ruby-crowned Kinglet, Gray-cheeked Thrush, Broad-winged Hawk and White-crowned Sparrow.

The following were seen on September 13: Chipping Sparrow, White-throated Sparrow, Sharp-shinned Hawk, Sparrow Hawk, Flicker, Hermit Thrush, Pigeon Hawk, Robin, Palm Warbler, Blackpoll Warbler, Savannah Sparrow, Marsh Hawk, Lincoln's Sparrow, Gray-cheeked Thrush, White-crowned Sparrow, Horned Lark and Yellow-bellied Flycatcher.

5. *Fifth Wave.* On September 16 the bulk of the Rusty Grackles arrived. A few had been seen the day previous, but only scattered individuals composing the vanguard of the large, noisy flocks to follow. The area of highest pressure was off the New England states, while the low pressure centered in Kansas. The barometer stood 30.0 inches, temperature 50°, and an easterly wind with a cloudy sky. While this was one of the smallest of the sharply defined waves, it presents a marked contrast to most of the others. Although the area of highest pressure was not near Isle Royale, as during most waves, the barometer stood at 30.0 inches, which was higher than for the area to the west and south; the wind was from the east and the sky cloudy in contrast to the northwest wind and clear sky of the other waves.

6. *Sixth Wave.* On September 18 the high area was far to the east (Maine) and the low centered over Kansas. The barometer stood at 29.8 inches, with a clear sky, northeast wind, and a temperature of 52°. Like the last this was comparatively a small wave and only involved a single species, the American Pipit, which came in large flocks numbering from perhaps 100 to 200 birds.

V. THE RELATION OF WEATHER TO MIGRATION.

Cooke ('88, p. 16,) makes the following statement in regard to the relation of temperature and barometric pressure during migration, "The area of the lowest pressure is never stationary but constantly moving, and in an easterly direction. It may be moving northeast, east, southeast, and rarely north or south; but never northwest, west, nor southwest. The usual direction in the Mississippi Valley is a little south of east." Warm waves, which are associated with areas of low pressure, therefore begin in the northwest, and move toward the southeast. "It is a law of the movement of winds that they go toward areas of low pressure, and from an area of high pressure." "But an area of low pressure is followed by one of high pressure, producing an opposite effect, and the isotherms which bent north to welcome the coming of the low area turn rapidly southward before the icy breath which blows from an area of high pressure. Thus the cold and warm waves both come from the same quarter, and both move in the same direction; that is the direction in which the area of low pressure is advancing." It will thus be seen that the temperature and the direction of the wind over any given area are both associated with the barometric pressure

and the movement of its high and low areas, and since "low pressure is generally accompanied by clouds and rain, while areas of high pressure are cloudless" it will be seen that this important element is also associated with the barometric pressure. Thus we see that the four striking factors which influence migration, namely temperature, direction of wind, condition of the weather, and barometric pressure are correlated and work together, the same factors being always associated together and giving the same results.

To determine the true relation of these factors to migration we must discover the most favorable conditions for this movement, and then we can correlate the atmospheric changes which are taking place with the corresponding migratory movement. Of course, many birds are constantly passing to the south throughout the fall, irrespective of the weather conditions, but the changes which will set great numbers moving onward simultaneously must be the ideal conditions for migration. If this be true the time to study this relation of the weather is during the great waves.

TABLE OF BIRD WAVES.

Date.	Barometer.	Temperature, F.	Wind.	Sky.
	FIRST BIRD WAVE.			
Aug. 23	29.9	58	N. W.	Clear.
24	30.2	53	N. W.	Clear.
25	30.3	50	None.	Clear.
26	30.2	54	None.	Cloudy.
	SECOND BIRD WAVE.			
Aug. 30	29.8	56	N. W.	Clear.
31	30.1	46	N.	Clear
Sept. 1	30.1	52	N. E.	Cloudy.
	THIRD BIRD WAVE.			
Sept. 5	30.1	39	N. W.	Partly cloudy.
6	30.1	42	N. W.	Clear.
	FOURTH BIRD WAVE.			
Sept. 12	30.2	42	N. W.	Clear.
13	30.4	26	W.	Clear.
	FIFTH BIRD WAVE.			
Sept. 16	30	50	E.	Cloudy.
	SIXTH BIRD WAVE.			
Sept. 18	29.8	52	N. E	Clear.

1. *Influence of Wind.* A reference to the table of bird waves shows that on six days of the thirteen during which large waves were observed, the wind was from the northwest. Two days were without appreciable wind, on two, the wind was from the northeast, and upon other days it was from the north, east, and west, but upon none of them was it from the south, southeast, or southwest. A northwest wind prevailed the first two days of the first wave, the third and fourth days being without wind. The second wave commenced with a northwest wind, which changed to north on the second, and to the north-

east on the third day. The northwest winds prevailed both days of the third wave, while the fourth started with a northwest wind, and changed to west on the succeeding day. The fifth wave was peculiar in having an east wind and the sixth a northeast one, both of which brought birds of different species, and from a different direction than those with northwest winds. These two waves were also much smaller than the preceding ones. It will thus be seen that the great bulk of migration took place with a northwest wind.

2. *Influence of Temperature.* Since fall migration prevails at a time when the temperature is gradually falling, the records for a wave near the first of the movement would be much higher than those at the last, so this factor can be considered only in a relative way, i. e., we must not compare the temperature at the first and last of the season, but simply consider the temperature immediately preceding and following a wave. The average temperature for the thirteen days was 47°. This low average was partially due to two days of very low temperature. All the waves but one were on a falling temperature, and in this case the mercury had fallen from the day previous. As a falling or low temperature is the cause of the high barometric pressure, which in turn with the passage of the high, causes the northwest winds which are so favorable to migration, it will be seen that a falling or low temperature is perhaps the first requisite for the bird wave. The low temperature also influences the food of the migrants, killing off the insects, or driving them to shelter, and in this connection may prove to be very important.

3. *Influence of Barometric Pressure.* One of the most striking conditions was the high barometric pressure under which these large waves took place. On ten of these thirteen days the barometer stood at 30 inches, or above, the average of these being 30.17. The lowest pressure was 29.8, the average for all being 30.09. None of the waves took place on a falling barometer, but where there was a change the pressure was rising as: first wave 29.9, 30.2, 30.3, 30.2; second wave 29.8, 30.1, 30.1; third, 30.1, 30.1; fourth 30.2, 30.4. As before stated the direction of the wind is due to the relation of the areas of low and high pressure to the region under consideration, and it is in this connection that it bears upon the problem of migration phenomena.

Cooke in his discussion of the effects of atmospheric changes on spring migration shows that at this season the large movements took place on low or falling barometers, and stated that it probably would be found that in fall the opposite conditions existed and migration would occur on the rising or high barometric pressures. This was found true at Isle Royale and probably is true for all fall migration.

4. *Condition of the Sky.* It will be noticed that on 9 of the 13 days of bird waves the sky was clear, and on the remaining four it was simply cloudy, no waves occurring during rainy weather. In spring the waves usually occur during cloudy nights; in the fall, as witnessed here, the opposite is the case, and the bulk of the fall migration can be said to take place on clear nights.

5. *Summary and Conclusion.* From the data submitted we see that fall migration as witnessed at Isle Royale occurs, in the majority of cases, with a northwest wind and a falling temperature with its rising

barometer, and clear sky. (Cf. Smith, '07, p. 223.) It therefore seems evident that low temperature and high barometric pressure, with the prevailing northwest winds and clear sky which accompany them furnishes the most favorable conditions for the bulk of the fall migration. It will be noticed under the head of Migration Routes that a few birds prefer northeast instead of a northwest wind. The conditions which would be favorable for the migration of these birds would occur after the passage of a high and while the approaching low was still some distance off.

It is desirable that similar observations be carried on at other favorable localities in order to further test these conclusions, and determine whether they are of general application to the fall migration.

VI. ROUTES OF MIGRATION.

From the observations made during the falls of 1904 and 1905, it seems that Isle Royale lies directly in the path of a very strong migratory movement. In the fall there was a great massing of bird life. For some unknown reason the path of densest movement was very narrow, at least appearances pointed to such a condition. This apparent narrowness of the route through the island was strikingly shown on September 9 when a trip was made across it from Washington Harbor to Siskowit Bay. About 15 miles were traversed, embracing every environment from clearings to high hardwood forests and damp cedar swamps. Nearly a day was spent hunting over the clearing and adjacent forest near the head of the bay, but scarcely any migrants were observed. A few Black-throated and Tennessee Warblers and a few sparrows were seen, while an occasional Sparrow or Sharp-shinned Hawk was met. This was not due to a lack of food, as grasshoppers and other insects were very plentiful. At Washington Harbor the reverse was the case; here on September 9 and 10 I saw many migrants, the majority of which were not seen at Siskowit at all. These observations at the harbor were made in the morning before leaving and in the late afternoon of the following day when I returned from the bay. While at Siskowit scarcely a bird was heard passing over, although at the harbor they could be heard throughout the night. The path apparently extended lengthwise of Isle Royale with Washington Harbor and the region lying between it and the north shore of the island as its diameter.

In a recent paper, Taverner ('05) makes the statement that perhaps a migration route lies between Isle Royale and Keweenaw Point. From the observations made on the island, I am led to believe that such a route does exist and also one lying much to the west of this point, perhaps to the Apostle Islands and the mainland lying Southwest of them. These conclusions were drawn from a consideration of the following facts. The route taken by the majority of the migrants, both those which passed slowly across the island and those observed flying overhead, whether by night or day, lay nearly southwest. During the latter part of August and parts of September, the nights were unusually bright, so that migrating flocks could often be seen high in the air even when not crossing the face of the moon. The cries of migrating birds, heard mostly on cloudy nights, usually came from a

northeasterly direction and died away in a southwesterly one. Certain birds, as the Thick-billed Red-wing Blackbird and Lincoln Sparrow, which were found commonly at the island, are very rare or do not occur at all in the region directly south or southeast of it. The Thick-billed Red-wing has never been taken at any point in southern Michigan. These birds, being of western origin, have gradually worked their way east where they have found suitable breeding grounds, but it seems probable that in their fall migration they move westward and join the throng passing down the migration route traversed by their ancestors. It seems probable that the greater portion of the migrants which leave Isle Royale, moving in a southwesterly direction, continue thus until they reach the Mississippi Valley, where they are joined by birds from other regions, and all move down this great highway of bird migration.

It was observed that nearly all the large bird waves were associated with northwest winds. As the birds probably take a southwest course this gives them the beam wind which seems to be most favorable for their flight. Of course it was impossible to tell from what direction the birds came to Isle Royale, but it seems reasonable that they should choose a beam wind when leaving the mainland, since they arrived shortly after at the island flying with such a wind. If this proves to be true, the majority of the birds coming to Isle Royale are from the north or northeast.

The data for the supposed route to Keweenaw Point is slight compared with that for the southwestern one. Two species, the Rusty Grackle and the American Pipit, were observed migrating in this direction. During their flight the wind was from the northeast giving them the beam wind which a number of observers have noted to be the one preferred by hawks and gulls during their migration. Under "Perils of Migration" an instance is cited where a number of birds were caught by a storm while crossing to the east of the island and were driven to Washington Harbor. These birds were possibly crossing to Keweenaw Point. Probably the majority of the birds which strike this point are from regions lying to the northeast of it, and arrive there on northwest winds as do those birds which migrate across Isle Royale. The theory that many birds skirt the Great Lakes, as brought out by Taverner, explains the absence of several species from Southern Michigan which is not done by the discussion of the routes from Isle Royale.

VII. THE PERILS OF MIGRATION.

Dixon in his "Migration of Birds," divides the perils of migration into three important classes: first, those arising from fatigue due to the mechanical part of season-flight; second, those arising from the natural enemies of each species; and third, those arising from blunders and fatalities on the way. These three classes were observed in varying degree during the fall migration at Washington Harbor.

1. *Fatigue.* Between the north shore of Lake Superior and Isle Royale, the distance is so short that unless unfavorable winds intercept them the older birds would have little trouble from fatigue due to the simple operation of flight; but the young, which often commence migration soon after being able to fly, would experience considerable

strain on their frail bodies in even so short a flight. This was vividly shown in the number of exhausted young found after every bird wave. During September, immature warblers and sparrows were often found in the morning in an almost completely exhausted condition after their night's flight. This was especially evident among the Tennessee and Blackpoll Warblers. On the morning of September 13, following the day which witnessed the largest bird wave, I picked up many dead birds. Nearly all were warblers, the Tennessee seeming to have suffered most, although the Palm was a close second. A few immature Savannah Sparrows, one adult Yellow-bellied Flycatcher, and several young Flickers were also found dead. These dead migrants were seen in the clearing, along the roads, and on the banks of the stream. An examination of these victims showed no outward indication of the cause of their death. Only a few were emaciated to any extent. It was a noticeable fact, however, that none of the birds found dead were in the prime, fatty condition of most of the other migrants taken. The conclusion therefore seems probable, that the birds must be in the best condition possible to make a successful migration flight, and that the greatest mortality among the migrants lies in that class which for some unknown reason are not in prime condition. As there were no other reasons evident which could have brought on this high death rate, it is probable that death had been caused by severe exertion, coupled perhaps in a few instances with lack of food and unfavorable weather conditions in which to recuperate. This seemed the more plausible considering the fact that in only a comparatively few cases were the victims adult birds, while, as before stated, many of the immature warblers and sparrows had only been able to fly for a short time.

After heavy storms, especially those from the southeast, many adult as well as young birds were found in an exhausted condition, their plumage presenting a dilapidated appearance, the wing and tail feathers broken, and showing general evidence of a hard struggle with the wind. Some of these birds may have been caught by the storm while crossing from the north shore to the island, but as the birds appeared to be blown before the wind I think that at least part of them were overtaken while crossing the lake considerably to the east of Isle Royale, perhaps toward Keweenaw Point. Overtaken by the storm and with no place to take refuge they were gradually blown in the direction of the island where they were found the succeeding morning in such an exhausted condition. Some of these birds would even allow themselves to be picked up and handled without showing any fear. The birds which suffered most were the Palm and Tennessee Warblers. Michael Hollinger, a resident on the island for several years, told me that often, especially in spring, he had seen Washington Harbor "literally covered" with floating birds which had succumbed in their struggle against the storms and had drifted in from the open lake. The peculiar shape of the harbor and the lake currents tends to mass floating bodies at this point. But the loss as shown by those collected at the harbor could be but a slight proportion of the vast numbers which must have perished in the open lake.

Several fishermen said that after heavy gales in late fall and early spring, the shore at Washington Harbor would be strewn with the life-

less bodies of birds thrown up by the waves. During the fall of 1905, birds were several times reported as lighting on the ships coming into the island, and the fishermen secured several which lit on their small boats after a storm, when about two miles from land. They reported the birds as very tame and allowing themselves to be handled freely. The birds secured were several small sparrows, Tennessee and Palm Warblers, a Saw-whet Owl, and one adult Robin. These birds were all encountered near the southwestern end of the island. They had probably been blown out of their course and were striving to reach the nearest point of land, as no birds would be coming from the south at this time of year nor would any so completely exhausted have attempted to leave the island.

2. *Natural Enemies.* Without doubt the greatest natural enemies of the birds during migration were the Sharp-shinned and Sparrow Hawks. At times the Pigeon Hawk made great havoc among the smaller birds, and the Owls also played a small part. Probably weasels and minks fed to some extent on the migrants, which they caught while the birds were resting. These animals, however, only destroyed comparatively few, as remains of their victims were seldom found. Likewise the Owls probably destroyed only those which came directly in their path, the abundance of the Varying Hare furnishing a food much easier to procure. This undoubtedly saved a large number of migrants. Of the other animals, the Lynx also fed largely on the Hares and so probably molested the birds very little, while the family of house cats kept at the club-house were more than supplied by the number of small birds which met death striking against the windows, etc.

The early migrants were preyed upon very little by the hawks, principally because the Sharp-shinned Hawk had not arrived in any appreciable numbers, and secondly, the great swarms of grasshoppers furnished an abundance of appetizing food. As the season advanced and both species of hawks grew more numerous, their effect on the bird life increased. None of the smaller birds were safe, away from the protecting boughs of the conifers and alders, and therefore were confined almost exclusively to the edge of the clearings. The Sparrow Hawks fed both on grasshoppers and on warblers and sparrows, while the Sharp-shinned fed almost entirely on the latter. During the bird waves the hawks became more numerous, this being especially true for the great wave of September 12. On this date great numbers of both Sharp-shinned and Sparrow Hawks made their appearance, as well as many of the Pigeon and a few Cooper's and Broad-winged Hawks. The Pigeon Hawks in particular timed their migration to that of their victims, appearing and disappearing with each successive wave, very few remaining on the island. The majority of the Sharp-shinned also kept pace with the retreating birds and by the time the bulk of the warblers and sparrows had passed they too had gone on. Among the birds which suffered most heavily may be mentioned the Tennessee, Blackpoll, and Palm Warblers, the Wilson's, Olive-backed, and Gray-cheeked Thrushes, and the Chipping and Savannah Sparrows. Great daring was shown by the Sharp-shinned Hawks. Sometimes so eager were they in pursuit of their prey that they would dart within a few inches of one's head.

3. *Blunders and Fatalities.* A comparatively new danger which besets migratory birds on the island is the fatal attraction of the lighted windows of resorts and the light-houses. During the migration scores of warblers, chiefly Tennessee and Palm, killed themselves by striking against the lighted windows of the Club-house which stood in a clearing near the Harbor. Many also met death by the same means at Washington Island, which is situated at the entrance to the harbor. Among the species killed at the latter place were the Tennessee, Blackpoll, Myrtle, Magnolia and Palm Warblers, Gray-cheeked, Olive-backed and Hermit Thrushes, and several species of sparrows. On September 2, during a hard storm which lasted several days, five Olive-backed Thrushes were found dead by Wood beneath the windows at the hotel, and on September 5, a Gray-cheeked Thrush was found dead at the same place. This latter was the first one of this species seen, no other being observed until September 12. All the birds were killed on the north side of the buildings. Sometimes after cloudy nights numbers of small birds would be found on the north porch of the Club-house in a dazed condition, probably from striking the building the night before. Both young and adults were found, the young being the only ones killed on clear nights.

The light-house keeper at Menagerie Island in Siskowit Bay, Mr. J. H. Malone, reported that hundreds of birds lost their lives every spring and fall at his light alone. It was mainly on cloudy nights that the birds struck the lighted windows and the lantern, but some were killed on other nights.

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Name.	August.														September.																				
	18	19	20	21	22	23	24	25	26	27	28	29	30	31	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Chipping Sparrow	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
White-throated Sparrow	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X				
Chickadee	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Sharp-shinned Hawk	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Sparrow Hawk	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Great Horned Owl	X		X	X		X	X		X	X			X						X						X		X		X	X					
Herring Gull	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Thick-billed Redwing		X	X	X	X	X	X	X	X	X		X		X		X						X	X	X						X				X	
Common Redwing	X																																		
Blue Bird	X	X	X	X	X		X	X	X	X	X	X	X	X											X	X									
Flicker	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Myrtle Warbler	X				X	X								X	X					X						X									
Kingfisher	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X					
Tennessee Warbler		X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X				X						X			
Canada Jay		X	X		X	X				X	X	X		X			X	X		X	X	X			X	X	X	X	X		X	X	X		
Red-breasted Nuthatch		X		X			X	X						X	X		X	X	X				X	X	X	X									
Crow		X	X		X	X	X		X	X	X			X			X	X	X				X	X	X	X	X	X	X						
Blue Jay		X		X	X		X	X	X	X		X		X	X		X	X	X		X	X	X	X	X	X		X		X	X	X		X	
Junco		X	X	X	X	X	X	X	X	X	X			X	X		X	X	X		X	X				X			X						
Night Hawk		X	X	X	X	X	X	X	X	X	X	X	X	X	X																				
Chimney Swift		X																																	
Pileated Woodpecker		X		X	X	X				X			X	X	X			X	X							X		X	X	X		X			
Phoebe			X		X		X							X	X				X							X									
Redstart			X	X		X	X	X		X		X			X			X		X	X	X				X									
Least Flycatcher			X	X	X	X	X	X	X	X	X	X	X	X	X		X		X			X			X	X		X							
Vesper Sparrow					X																					X									
Hermit Thrush					X	X	X		X	X	X	X	X	X			X		X	X	X	X	X		X	X	X	X							
Hummingbird			X		X																														
Spotted Sandpiper			X	X	X		X		X	X	X				X				X			X				X				X					
Song Sparrow				X		X	X																												
White-rumped Shrike						X																													
Cedar Waxwing						X	X			X		X	X	X			X			X	X			X		X		X	X	X		X	X	X	
Pigeon Hawk						X		X	X		X	X			X			X		X	X			X	X	X	X			X					
Robin					X								X							X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Olive-backed Thrush			X	X			X	X	X	X		X	X	X	X	X	X	X	X	X		X	X			X		X	X		X				

Name.	August.														September.																				
	18	19	20	21	22	23	24	25	26	27	28	29	30	31	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Golden-crowned Kinglet					X		X	X	X	X		X	X	X	X	X	X	X	X	X		X	X	X	X	X			X	X	X	X	X	X	X
Brown Creeper					X												X						X						X	X	X	X			
Loon					X						X						X	X	X	X						X									
Winter Wren					X	X	X	X		X	X			X					X						X	X		X	X			X			
Hairy Woodpecker						X					X											X		X	X	X									
Bald Eagle							X												X					X						X	X				
Pied-billed Grebe				X	X	X	X	X	X		X	X	X	X	X	X	X	X			X					X				X	X	X	X	X	
Raven						X			X	X				X							X	X								X					
Cooper's Hawk							X																			X									
Wilson's Thrush							X	X	X	X	X	X	X	X	X		X	X		X	X		X			X		X							
Solitary Sandpiper							X					X				X	X	X	X							X		X	X						
Alder Flycatcher									X																										
Magnolia Warbler											X	X	X	X					X		X		X	X	X	X									
Palm Warbler											X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Oven Bird											X	X	X	X								X	X	X	X	X									
Purple Finch											X																								
Bay-breasted Warbler											X	X	X	X	X	X	X	X	X	X						X									
Blue-headed Vireo													X													X									
Acadian Owl													X																						
Black-poll Warbler								X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X						
Black and White Warbler														X																					
Savannah Sparrow														X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Black-throated Green Warbler																			X			X		X		X									
Yellow-breasted Flycatcher																											X								
Grinnell's Water Thrush											X	X	X	X	X	X	X	X	X	X	X	X			X	X									
American Merganser																		X																	
Baldpate											X	X							X	X															
Green-winged Teal																		X																	
Marsh Hawk								X	X					X									X		X	X	X								
Kingbird																		X																	
Wilson Warbler														X					X																
Catbird																										X									
Black-throated Blue Warbler											X															X									
Nashville								X	X	X				X	X							X			X	X									
Philadelphia Vireo																										X									

Red-eyed Vireo																										X									
Lincoln Sparrow																										X	X	X	X						
Connecticut Warbler																										X									
Ruby-crowned Kinglet																			X		X	X	X			X			X						
Gray-cheeked Thrush																			X							X	X	X	X	X	X	X	X	X	X
Broad-winged Hawk													X						X							X									
Wilson's Snipe										X																									X
Downy Woodpecker																		X	X		X					X			X	X	X				
Arctic Three-toed Woodpecker																					X					X									
Yellow-bellied Sapsucker																											X								
Horned Lark																											X	X	X	X	X	X	X	X	X
Rusty Grackle																													X	X	X	X	X	X	X
White-crowned Sparrow																										X	X	X	X	X	X	X		X	
Canada Goose																														X					
Yellow Legs												X				X	X												X						
Pine Siskin																																X			
Osprey																												X				X			X
American Pipit																																X	X	X	X
Sharp-tailed Grouse																								X											
American Scaup															X																				
Olive-sided Flycatcher																	X																		
Northern Shrike															X								X												

THE ECOLOGICAL SUCCESSION OF BIRDS.*

BY CHARLES C. ADAMS.

"Of all truths relating to phenomena, the most valuable to us are those which relate to their order of succession. On a knowledge of these is founded every reasonable anticipation of future facts, and whatever power we possess of influencing those facts to our advantage."—JOHN STUART MILL.

"Indeed, some geologists seem to take pride in lack of knowledge of principles and of their failure to explain the facts observed in the terms of the elementary sciences. I have heard a man say: 'I observe the facts as I find them, unprejudiced by any theory.' I regard this statement as not only condemning the work of the man, but the position as an impossible one....The geologist must select the facts which he regards of sufficient note to record and describe. But such selection implies theories of their importance and significance. In a given case the problem is therefore reduced to selecting the facts for record, with a broad and deep comprehension of the principles involved, a definite understanding of the rules of the game, and appreciation of what is probable and what is not probable; or else making mere random observations. All agree that the latter alternative is worse than useless, and therefore the only training which can make a geologist safe, even in his observations, is to equip him with such a knowledge of the principles concerned as will make his observations of value."—PRESIDENT C. R. VAN HISE.

I. INTRODUCTION.

Almost every observer of animals has noted that certain kinds of birds are usually found associated in certain conditions, as, for example particular species of sandpipers and plovers upon the sandy beach, or the Meadowlark and Dickcissel upon certain prairies; but this is rarely considered a subject worthy of serious scientific study. To discuss the significance and value of such ecological study and suggest phases for investigation is the object of this paper. By the ecological distribution of birds is meant that correlation between environmental conditions and the occurrence and association of certain species of birds. In such study special attention must be devoted to the places of breeding; nevertheless the associations of birds at all seasons of the year are of importance. It is not the isolated occurrence of these species, but their relative abundance, the association of certain species, and their persistent occurrence in such conditions which is significant. In the literature of ornithology there is a vast amount of isolated data bearing on this subject, but very little of it has been organized and systematically studied.

When once the facts and general ecological relations have been determined, so that the representative bird associations or societies of given localities have been correlated with their proper environments it will then be possible to determine how one society becomes transformed into another, whether this is due primarily to other birds or to other environmental influences. A knowledge of the succession of bird societies and of the laws of change will not only lead to new ideas as to the influence of the environment, but will also have a

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marked influence upon the practical field studies of the bird student. It should lead to a more intelligent understanding of the relation of birds to the world about them, or even better, to the world of which they form a part.

Attention should further be directed to the fact that simply the occurrence of the bird in a definite habitat is not by any means the sole aim of such work. The influence of the environment should be studied in its bearing upon all phases of bird life. Not only should the most favorable habitat or optimum be recognized, but also the influence of the less favorable conditions; thus the nesting site, composition of the nest material, food, abundance, feeding grounds, migrating habits and all like relations are needed for an adequate and exhaustive study of the ecological distribution and succession of birds.

It is therefore not surprising that such requirements will be difficult to meet because the facts themselves are difficult to secure. Then there are further difficulties which are due to the limitations of the student himself, and are psychological in their nature. As examples of this class of difficulties two may be cited, because they are of frequent occurrence in all kinds of scientific work and not by any means confined to the study of birds. For, contrary to our youthful ideas, naturalists have the same limitations as humanity in general! We may divide naturalists into two classes, depending upon their primary type of mind. First, those who tend to see only the infinite detail of isolated facts and observations. This type of mind is particularly impressed with the multiplicity and variety in nature, and is one to which a general statement is almost a cause of irritation because there are usually exceptions to any general statement. The constructive imagination seems feebly developed in this type. To this class belongs many extremely valuable and useful students, because of the data which they, often with extreme conscientiousness, collect. They are collectors of facts rather than students of relations. To the second class belongs that type of mind whose primary interest is in generalizations, principles, relations, and which tends to neglect isolated facts and observations. The constructive imagination is liable to be developed in this type. This includes many extremely valuable and useful students on account of their tendency to condense, sift and formulate great masses of isolated facts. They are students of ideas and relations rather than collectors of "facts."

Each class, especially the well-marked types and extremes, often finds it difficult or impossible to understand the point of view of the other class. This frequently leads to misunderstandings and often to mutual contempt. Cope and Marsh clearly illustrate these two types of minds among our American naturalists.

By this time some may wonder why this subject has been introduced. It has been with a definite purpose, because frequently these opposed points of view cause delays in the development of many subjects. Thus a forewarning to students of bird ecology may produce good results if the individual student makes a conscious effort to counterbalance such deficiencies as go with his particular type of mind. In the past, details have tended to produce confusion through the neglect of general ideas. It is rarely that a word of warning on this subject is out of place, because the balanced "golden mean" investigator is never too abundant.

The quotations at the head of this article have an immediate bearing upon the subject at this point.

Not only is habitat preference, the association of avian species, their succession, and the laws expressing these relations of much interest, but they are of much importance scientifically as well as in a practical way. It is therefore desirable that naturalists realize the necessity of understanding the "rules of the game" if the true relations of birds are to be studied to the best advantage. No adequate substitute has yet been devised to replace a grasp of general principles.

Throughout this paper emphasis is placed on the *definiteness* of the dominant major environmental influences and complexes because the irregular features have apparently received undue emphasis and have retarded the recognition of certain important definite relations.

II. REPRESENTATIVE LITERATURE ON HABITATS AND SUCCESSION.

1. *Habitat Preference.* The American literature on habitat preference and succession, as a subject of special investigation, is very limited. By succession is meant the change or replacement at a given place of one or several species (an association) by others; as when a swamp is invaded by a dune and the representative swamp birds are replaced by those of the dune; or even again when the dune becomes fixed by vegetation and is inhabited by still another association of bird life. This is a much neglected subject; however, isolated observations on habitats are abundant in the biographies of the various species. The fragmentary character of these biographies tends to make them composite and they lose what peculiarities they may have which are due to a response on the part of the bird to its particular conditions of life. These unfortunate limitations clearly show that here is an extensive field worthy of careful investigation. The work already done will be a useful guide in many cases, but the student who wishes to develop this subject must turn to the fields and forests rather than to the literature, both for his inspiration and his data.

Perhaps a further word should be added concerning the limitations of the *composite* life-history method, as this will aid in making clear the kind of work needed in the future. This composite or generalized method of describing habitats and life histories and the response of birds to them, tends to lay undue emphasis upon the *average* conditions of life and habits, and tends to neglect those *detailed responses* to the environment which reflect the laws of local influence. These results are similar to those produced by systematic students who are "lumpers" and who do not recognize local races or varieties. Thus a nest may be built upon the ground at the base of a shrub or bunch of grass, or in the brush, but what conditions determine such sites? In a dry meadow a Song Sparrow may build directly upon the ground, but in a swamp, in order to have a dry nesting site, it builds in a willow shrub. In many cases the causes of these differences will be difficult to determine, but in others it is a relatively simple question for any one familiar with the species to solve. There are also geographic variations of habits as well as those of habitats just cited, and for this reason it is necessary not to confuse such variations with those confined to some restricted area. These local and geographic relations are very intimately related, but they are sub-

jects which can only be worked out in detail when local studies give proper attention to local environmental responses.

In the following account of the literature no attempt is made at completeness, but the papers cited are believed to be representative. These papers will help to give some idea of the kind of observations and records already made, and will be suggestive as to future work. Mention will first be made of the literature on habitat preference, and then of that on succession.

By far the best discussion we have found on habitat preference of the birds of a given region is that by Townsend ('05) on Essex County, Massachusetts. The primary avian environments are described, the representative birds listed, and their preferred habitats are briefly discussed. Thus, the ocean and its birds, the sand beach and its birds, the sand dunes and their birds, the salt marshes and their birds, and the fresh marshes and their birds, give a general idea of the subjects treated. Regarding the birds of the sand beaches, he remarks: "Among the Plover, the Black-bellied, Semi-palmated, and Piping Plovers are above all birds of the beach, although the first two are occasionally found in the marshes, while the last-named rarely strays from the beach and the adjoining sand dunes. The Golden Plover, although at times found on the wet sands, is much more likely to hunt for food on the dry sands above the highest tides, or still farther inland, while the Killdeer generally avoids the beach altogether, preferring the fields" (p. 21). And regarding the birds of the sand dunes he remarks: "Savanna Sparrows nest in numbers at the foot of clumps of tall beach grass throughout the dunes, and on the edges of the tidal inlets from the marsh. The nests of the Red-winged Blackbirds and the Bronzed Grackles are abundant in the bogs and groves of the birches. The Crow, in the absence of tall trees, builds perforce in the stunted pines and birches, at times only ten or twelve feet from the ground" (p. 34). In the case of the Crow, note that he records the response to the dune environment.

While Townsend recognizes changes in the environment, as in the dunes and beach (pp. 21, 30), yet he does not see their relation to the bird life in the definite way in which he sees their habitat preferences, nor does he appear to clearly recognize the fundamental relation of association within the breeding habitat. To him the environment is static. However an excellent feature of his work is the record of seasonal changes in the bird life of the various habitats. In this connection attention should be called to certain papers which will greatly aid in the study of the dynamics or changing environmental factors which influence sea or lake shores bordered by dunes and swamps; conditions represented on the Massachusetts coast. Gilbert ('85) has discussed the general principles and topographic features of lake shores and Gulliver ('99) the shore line of the sea. But in addition to these physiographic forces, the vegetation also has a dominating influence upon bird life. For general principles relating to this subject Cowles ('01) should be consulted for his discussion of the vegetation of inland shores and dunes, and Ganong ('03 and '06) for his treatment of the Atlantic coastal conditions. These authors discuss

the succession of the vegetation, a factor of the utmost importance in the study of avain succession.

While considering Townsend's results, it may be well to outline briefly a general succession of bird life along the shore as indicated by his records. It is evident from the map accompanying his volume that the currents and waves are constantly modifying the coast line and forming spits, bars and islands; and that the barrier beach area is increasing, and thus tending to become continuous at the expense of some of the ocean habitat. As the continuity of the beach develops, the area of swamp land behind it tends to increase and thus to further restrict the open water and increase the swamp habitat. The beach sands, once free from the waves or ground water, are caught up by the winds to form dunes, and may migrate into the swamps and thus transform them. Thus with the extension of the beach the sea birds are replaced in dominance by the shore birds, and a succession is produced. In a similar manner the dunes encroach upon the swamp, and swamp birds are succeeded by those of the dunes. As the wandering dunes become anchored by vegetation and forests grow upon them, still other birds will invade them. Thus all stages may be expected, from ocean to beach birds, onward to those characteristic of wandering and fixed forested dunes. These relations are outlined simply to indicate the problem and its causes, which need detailed investigation.

In Michigan a few habitat studies have been made. One in the Porcupine Mountains, on the south shore of Lake Superior, and another on Isle Royale. Both are by McCreary; the paper on the latter area is published in this volume. The summer birds of the Porcupine Mountains are listed (McCreary '06) by selected localities and the habitat preferences are discussed as follows: water birds, birds frequenting the shores and banks of streams, birds frequenting grassy meadows and alders, birds frequenting tamarack and cedar swamps, birds frequenting hemlocks and maples, and birds frequenting the cliff and mountain top. In its emphasis upon habitat preference this paper is the only one so far seen which at all approaches Townsend's discussion of this subject. McCreary's work was done without a knowledge of Townsend's.

In southeastern Michigan, Brown ('06) made a locality study and outlines the habitats as follows: birds found in orchards, birds of the open woods, birds of the open fields, birds of the thicket, and birds of the marshes and river. Brown's paper is intermediate in character between the preceding papers and those of an economic nature, to be mentioned later, because the area studied has been so much influenced by man.

There are a few papers which, although primarily faunistic or geographic, contain habitat data. Such, for example, is Ridgway's ('74) discussion of the birds of the Wabash Valley and ('89) the birds of the Illinois prairie (pp. 13-16). An exceptionally good paper of this character on the Louisiana birds is by Beyer, Allison and Kopman ('06), although its aim and method of treatment differs from that of Townsend. The bird life is, however, closely correlated with the vegetation and the physical conditions of the State.

The papers previously mentioned have been written from a regional standpoint. The study however of all the various conditions frequented

by a given species or some natural group is also an important and neglected method of ecological study which possesses certain important advantages. As an illustration of this method may be mentioned Palmer's ('00) study of the Maryland Yellow-throat. He has shown that different varieties have different habitat preferences. Jacobs ('04) has given us an interesting habitat study of a single species in Pennsylvania, the Golden-winged Warbler.

Let us now turn to another class of habitat studies, those which through man's influence throw only a subordinate light upon "natural" habitats and succession, and are primarily of economic importance but contain valuable habitat data.

An interesting and rather unique paper belonging to this class, based on observations in Southeastern Michigan, is by Watkins ('00). It is entitled 'Michigan Birds that Nest in Open Meadows.' A few of his statements explain his point of view: "To make more plain the limit and scope of this treatise, which, of necessity must be longer than I hoped, I will include in my list only such species as I have found nesting upon the ground in the open fields and meadows, excluding those found nesting upon the boundary fences or ground; also those nesting in the open marsh land which are undrained and boggy to the extent of being unfit for hay or pasture" (p. 67). The paper contains numerous notes on the habitat preference and variations in these traits.

By far the most comprehensive and thorough study of any limited farm area is that by Judd ('02) of a farm in Maryland. In this paper habitat preferences are clearly recognized, and discussed rather fully (pp. 12-20). The birds are associated thus:—birds that nest in the open fields, birds that depend on covers, birds of less limited distribution (consists largely of remarks on haunts), and birds of varied distribution. His last two sections are rather miscellaneous in character and show that the principles of classification for habitats were not clearly defined in his own mind.

The only other paper discussing habitat preference in detail is also the latest upon the subject, and is by Forbes ('07). This is a preliminary report on a bird census across the corn belt of Central Illinois in the early autumn; a study of the feeding grounds and preferences as influenced by the dominant crops of the area traversed, corn, pasture, and stubble. By means of this census, the habitat preferences for different crops and the association of species in them is statistically determined. The paper is particularly suggestive for its bearing on the subject of dominance; however, the suggested method of study has even greater significance when applied during the breeding season. Doubtless opinions will vary as to the validity of the method as applied by Forbes, even by those who would approve of it for the detailed study of a limited area, or a breeding habitat. For large areas some cooperative method may be necessary.

2. *Succession.* Turning now to the literature on succession, it is found to be extremely limited in amount. So far as known to the writer, only two American authors seem to have realized the existence of succession. In his discussion of the biotic succession in the Porcupine Mountains of Michigan, Ruthven ('06) clearly included the birds, although they did not receive separate treatment, and might for this

reason be overlooked. His position is clearly stated (p. 43) as follows: "Owing to the dependence of forms of life on their environment, biotic changes are necessarily closely related to environmental changes. These biotic changes may occur in two ways; the forms must either be able to respond to the new conditions, or be supplemented by other forms. That they tend to become adjusted cannot be questioned, but in many cases at least, this adjustment lags behind the changing conditions, and the forms are replaced by others from adjacent habitats which are adjusted to the conditions toward which the particular habitat is changing, thus bringing about a succession of societies." In speaking of the biota of the hard-wood forest he further says: "This region has been reserved for the last, for the conditions are evidently those toward which the other habitats tend to be changed under the present conditions....This society thus represents the climax society of the region. It consists of the forms that are adapted to or associated with the conditions which prevail in this region in the last stages of the mutual adjustment of all the environmental processes. As the processes become adjusted to one another, the habitat of the climax society is increased at the expense of the other habitats, and the associated biota tends to become of general geographic extent in the region."

The only other paper discussing avain succession is that by Frothingham ('06), and this is not a "natural" succession but one influenced primarily by man. He clearly expresses a bird succession correlated with the reforestation of burned lands. The area studied is the Michigan forest reserve on Higgins Lake. The region was originally covered with White and Norway pine, but repeated fires first killed off the pines, later the oak and maple; and finally the dominant vegetation is sedge, sweet fern, huckleberry and prairie willow. With the fire protection afforded by the reserve, Frothingham anticipates a reversal of the above succession of destruction, and further remarks: "With the types of vegetation which mark the different stages of the plant succession just described there seem to be correlated certain definite bird forms. These forms are for the most part such as frequent observations in northern Michigan have identified as generally characteristic of the respective environments." This is followed by lists of birds characteristic of different kinds of vegetation. While these lists do not correlate perfectly with the implied succession, yet the general statement of the problem is clearly expressed.

The burning of forests has long been known to change the character of the vegetation and fauna of areas, but this is often referred to as the change of a "life zone." Thus Merriam ('99, p. 47) states that a fire in the Canadian zone on Mt. Shasta is followed by the Transition zone and remarks: "But in the meantime a new growth of Shasta fir has started, and in ten or twenty years is likely to overtop and drown out the Transition zone species, enabling the Canadian zone to reclaim the burn....But on the steeper slopes, especially rock slopes, if the vegetable layer is burned off, the (lower) zone which creeps up to replace the (higher) one destroyed becomes permanent or nearly so....Deforestration of an area therefore tends to lower its zone position." Birds are not mentioned in this discussion nor the relation of

"zones" to the general problem of succession. Such "zones" are thus only particular phases of succession.

It is thus seen from the above outline of literature that habitat preferences have been outlined for a few widely separated localities and for some agricultural conditions, but there has been no comprehensive discussion of the problems of habitats and succession, even in a preliminary manner, either from a scientific or economic standpoint. This fact seems rather remarkable in view of the great utility of a knowledge of the general principles underlying economic practice. There are, however, certain phases of biotic succession which have been discussed by a few authors. These subjects have either been discussed in a very general manner or are detailed discussions of special regions or groups of plants and animals. For this reason, perhaps, their bearing upon other groups than those specifially mentioned are very likely to be overlooked by those who take little interest in any subject or discussion which does not specifically mention their specialty or locality. This phase is mentioned in order to show that while avain successions have been considerably neglected, advances have been made elsewhere, by means of which some general principles appear to have been fairly well established. This is particularly true of plant succession, as shown by the writings of Cowles ('01), and in considerable detail by Clements ('05). The discussion by Clements will be particularly valuable to the student of avian succession.

III. THE MAJOR AVIAN ENVIRONMENTS.

As has been seen in the preceding review of the literature on haunts, no comprehensive discussion has been given of the environmental influences or ecological distribution of (extra-tropical) North American birds. Various authors have discussed their geographic distribution, and certain geographic variations have been referred to certain environmental influences, but a general ecologic treatment, as contrasted with a primarily faunistic one, has not been made. This is remarkable when we recall the fact that the collections of North American birds are, considering the large area concerned, the best in the world both as to quality and as to quantity (Stejneger, '03). This means that there have been many trained collectors; but what has become of the notes and observations on the environments and conditions of life of these birds, which must necessarily have been known to successful collectors? Part of these observations have been published, and perhaps no one is to blame because more have not; but the point of significance is that we have, in fact, hardly made a beginning in the careful detailed study of the bird environment and its development as a distinct field of study. In common with the remainder of the North American biota, several general principles are known, but they do not appear to be current among ornithologists.

The following discussion and suggestions on the larger environmental units attempt only an outline of certain phases of the problem, in order to call attention to certain principles which seem useful as a background for the intelligent study of bird habitats and succession. From such a standpoint as this, the *dominant* influences of given areas and environments are of particular interest and of fundamental value. By focuss-

ing attention upon the importance of recognizing these dominant environmental influences, we may hope to escape some of the confusion which appals those who are keenly impressed with the chaos and complexity of the problem. These dominant factors are usually not single isolated forces, but resultants of several or many influences. Thus, as in the case of the vegetation, it is not one factor, but a complex, which influences different birds in different ways. Nevertheless there is what may be called a mass or dominant effect.

A major habitat unit may be considered as a combination of conditions which are dominant in a certain area. *The very dominance means that a relatively limited number of forces or complexes are operative.* With departure from such a center of influence the dominance changes, as other influences are encountered and other dominants are established.

When we consider that certain ecological groups of birds are world-wide in their environmental relations, it becomes evident that such characters are of fundamental importance. Thus water birds may occur in any part of the world where water is a dominant environmental factor. This is not a simple ecological group of birds, but one of the greater units of association which may be subdivided into many minor classes; as those which frequent the sea, and others the inland bodies of water. The shore birds form another natural ecological group, and also the inland birds a third. There may thus be considered to be three primary ecological groups of birds which are closely correlated with definite and dominant environmental influences: Thus:—

1. Water birds.
   Those frequenting the sea and the adjacent rocks on which they nest, and inland waters.
2. Shore and Marsh birds.
   Those frequenting shores of all kinds, seas, lakes, swamps and rivers.
3. Inland birds.
   Those frequenting deserts, grass lands and forests.

Of course these ecological classes are not sharply defined, and yet they are so distinct that they can be easily recognized. It should be noted that the above groups are closely correlated with certain dominant physical features of the earth—the sea, the shore and the inland environments.

The relative abundance and dominance of these classes of birds will be determined largely by the dominance of such physical conditions as most distinctly favor a particular ecological group. Thus at sea the water birds are dominant; on shore, the shore birds; and inland, still other kinds. The linear character of the shore habitat and the adjacent breeding grounds gives it a rather unique character, as the two other habitats occupy large expanses. However, the swampy, somewhat shore-like conditions of the far north most nearly approach, for the shore birds, the expansive character so usual for water bodies and inland areas.

In the present discussion the emphasis placed upon the inland vegetation does not mean that the dominance of other influences is not recognized, but simply that it makes a convenient and fairly reliable *index to many other environmental influences*, as, for example, the climate and topography. A further important advantage of the plant index is

that the science of plant ecology and many of its general principles and methods are applicable to birds. A general knowledge of plant ecology is therefore becoming one of the most valuable tools in the hands of the field ornithologist. Every field naturalist has observed the general correlation of certain birds with certain kinds of vegetation. This relation is clearly expressed by Ridgway ('89, p. 8) as follows: "There is probably no better index or key to the distribution of birds in any country than that afforded by the character of the vegetation: should this vary essentially within a given area, a corresponding difference in the bird-life is a certainty." This phase of the subject clearly illustrates the oft-repeated experience of naturalists that in order to thoroughly understand one subject—perhaps the favorite one—it becomes necessary to study another, or even several. Thus in order to know the bird life of a region it has become necessary to study the ecological relations of its vegetation.

The study of ecological plant geography is an extensive one, but many of the details, so important to the botanist, are of much less concern to the ornithologist, who needs primarily to know the major plant associations or formations and their successional relations. This implies ability to recognize dominance among plant species and the general method of transformation from the dominance of one to that of another.

By a plant formation is meant that association of species (or plant society) which is correlated with those conditions which tend to prevail over a large geographic area in the last stages of mutual adjustment of all environmental and biotic processes. Such an association or formation tends to occupy such an area to the exclusion of all others, and is thus a climax society.

But absolute dominance of a formation does not occur, because local conditions break the monotony where streams, water basins, bare rock, and similar influences may interrupt the desert, grassland or forest, and produce minor habitats and associations of both plants and animals.

It is not my purpose to discuss in detail the various plant formations of (extra-tropical) North America, but to outline those which are of evident ornithological utility. The following may be recognized provisionally:—

1. The Arid Deserts of Southwestern U. S. and the Mexican Plateau.
2. The Grasslands of the Great Plains.
3. The Deciduous Hardwood Forest of Southeastern U. S.
4. The Coniferous Forest of Eastern Canada.
5. The Giant Conifer Forest of the Pacific Coast and the Rocky Mountains.
6. The Barren Grounds or Cold Desert.
7. The Alpine Deserts.

A mere inspection of this list of avain and vegetational formations shows that the recognition of these large environments is relatively simple. It is also seen that they represent fairly definite physical or environmental complexes of such fundamental importance that there can be no doubt as to their general validity. As to the relative value, influence, boundaries, and the dynamic relations of these formations, much is already known, but not as an organized body of facts and prin-

ciples. It will also be noted that these regions do not closely correspond with current faunal areas, although there is a very close correlation in some cases. An avian formation may, in general terms, be considered the analogue of a vegetational formation, although this does not imply that they necessarily have the same boundaries.

As the literature treating of the vegetation of these areas is extensive and scattered, a few papers will be cited as an index to others:—

1. Arid Deserts; Bray, '06; Coville and MacDougal, '03.
2. Grasslands or Plains; Clements, '05; Pound and Clements, '00.
3. Southeastern Hardwoods; Cowles, '01; Harper, '06; Transeau, '05.
4. Eastern Canadian Conifers; Whitford, '01; Transeau, '03, '05-'06; Ganong, '03, '06; Harvey, '03.
5. Rocky Mountain and Pacific Conifers; Whitford, '05; Gray and Hooker, '81; Piper, '06; Young, '07.
6. Alpine; Merriam, '90, '99; Coville, '93; Fernald, '07.

These environmental unit areas as found to-day, are the result of many successions which, in some cases at least, reach rather far back into the past. This is because some occupy ancient land areas, such as much of the Southeastern Hardwood area. On the other hand, some occupy relatively new regions, that is, at least with regard to the dominant factors now in control, as in the glaciated part of North America and on the Coastal Plain. So far as the present is concerned such relations clearly show that these areas are only the end results of extensive past changes or successions which represent the terminal branches and cross sections of development. It is to the study of such regions and associations that we must turn for the fundamental organization or associational relations of the various elements which compose not only the environments but also the associations of animals.

In order to make as definite as possible the *structural and ecological characteristics* of these formations, certain general relations are here formulated. Throughout this paper it should be remembered that the individual birds and associations of given areas form the units of comparison. Such a distinction is necessary because many species show considerable geographic variation in habits and in the habitats frequented. The writer clearly recognizes the risks and difficulties of such an attempt. They are deliberately put in their present form to *invite criticism and qualification* from field workers. It is desirable to know the validity of these formations, their internal ecological relations and dynamic tendencies, their relation to dominant environmental influences, etc. A complete list is not attempted, and some of the statements may be only fragments of larger generalizations; but it is just such relations as these which will develop if the entire subject is considered critically and synthetically. Some of the leading characteristics of these larger environmental units and their avian *formations* may be briefly outlined as follows:—

1. The dominance of a limited number of physical conditions or complexes, as climate, topography, vegetation, animals, etc., in a given area produces the primary environmental units and formations.

2. Secondary environmental dominance is shown by a secondary avian association. Thus in the Northeastern biotic center there is a secondary dominance due to water basins in the forest area.

3. A formation or climax society is composed of a relatively (and usually absolutely) limited number of species which are dominant in a given environment of geographic extent. Such dominance, in general, implies extensive range, relative abundance, and ability to indefinitely succeed or perpetuate itself under given conditions.

4. Where dominance obtains, avian variety is limited so that the greatest diversity occurs where local influences prevail, and at the margins of the formation.

5. Correlated environmental and biotic dominance produces what may be considered a *biotic base*, stratum, or optimum, from which departures may be considered less favorable. This is a relative equilibrium, resulting from complete environmental and biotic adjustment, under given conditions.

6. In each formation there is a normal inter-adjustment of the avian species and individuals, in addition to the adjustment with the dominant physical environment. The former is dominated by their structure, habits, and the instincts or behavior; hence the colonial breeding or spacing, migration, etc.

7. Each large environmental area or formation tends to have a full complement or set of species, of diverse but supplementary ecological character, such as water, shore or inland birds. One set is likely to be dominant.

8. Relative stability in an association is correlated with the climax dominance, and generally with extreme and slowly changing local influences. Fluctuation is correlated with intermediate conditions.

9. Diversified associations and isolation are greatest with imperfect dominance, but dominance itself produces isolation of the climax association. This diversification produces associations surrounded by others and hence their isolation.

10. The taxonomic elements in different formations vary much, but there are close analogies in the kinds of taxonomic and ecological groups in different formations,—as the Mniotiltidæ of the New are represented by the Sylviidae of the Old World. *Cf.* Osborn '02. LeConte, '50, p. 239. *Cf.* No. 7.

11. The roughly zonal arrangement of societies about the climax society (formation) or the environmental optimum, is primarily due either to local reversals, the lagging influence of local or neutral conditions, or to the influence of adjacent formations. This is a result of the retardation of the complete cycle of successions.

12. The primary environmental conditions tend to encroach upon all others. The local conditions thus tend to become transformed in the direction of the dominant environment and to be appropriated by it. The corresponding avain associations are thus given a definite dynamic trend.

13. The mobility of birds during the breeding season is very generally overestimated. The presence of the nest and young renders them for a time relatively sedentary. There are many causes influencing this, such as other individuals, proximity of food for young, homing, instinct, etc.

IV. Minor Avain Environments and their Associations.

We have seen that the larger geographic environments or formations are characterized by definite conditions and associations, and at the same time that even throughout these favorable regions the climax association is not distributed with absolute uniformity because of local variations in the physical features, such as vegetation, water basins, streams, mountains, etc. For the student of local bird life the real work begins when one attempts to examine into the causes and influences exerted by these conditions which break the monotony of the formation and make possible a diversified avifauna. But birds do not always respond as closely to slight local influences as does the vegetation, and for this reason one must learn by experience just what size of units must be used. Thus in the forest a few wind-falls will attract but little attention, but a burn of a few acres will have a noticeable influence in harboring those species of birds which frequent openings; while swifts and swallows ignore many local influences which dominate other species.

It should also be noted that whenever possible it is of distinct advantage to examine all habitats in their original state, uninfluenced by man.

Instead of discussing the leading features of local conditions and their societies or associations in detail, only an outline of them will be given, and that in a form to facilitate use and revision.

1. Minor environments are primarily dependent upon local conditions, and are thus in a sense correspondingly independent of the dominant forces of the region. This is, of course, a relative condition.

2. Minor environments are, as a rule, relatively limited in area. In general their limited area favors their short duration, but age is primarily a result of the rate of change.

3. Marked isolation, even when of extensive linear extent,—as a shore line, along a stream, or an elongate rocky ridge,—is also characteristic of minor environments.

4. Minor environments tend to become encroached upon by the dominant regional influences and ultimately to become extinct. The succession of societies in local habitats is a declining one, while that of the geographic or climax habitat is an increasing and ascending one.

5. Local habitats produce most of the variety within the dominant area, and make possible a diversified avifauna. The structural differentiation within a formation (zones, etc.) is thus largely, in addition to variations in the formation itself, of local origin.

6. Local associations or societies, in general, furnish the essential clues as to their earlier successions which have attended the evolution or development of regional dominance. The variations in these are due both to the kind of life and to the influence of adjacent associations and centers of dominance.

7. Marginal societies are particularly liable to variation in composition, due to the combined influences of adjacent formations or centers of dominance as well as to local conditions.

8. Comparative studies of local habitats will form the most general and practical guide in the determination of the successions in the formation.

9. Local habitats and societies, in common with the larger environ-

mental complexes, are characterized by the dominance of few physical and biotic factors, and by a limited number of species.

V. Avain Succession.

1. *General Remarks.* Since the breeding grounds are fundamental importance in the ecology of birds, the study of them in such situations furnishes the greatest source of insight into their life relations. By an avain association, formation or society is meant different combinations of species which *regularly occur together in the same breeding habitat or area.* These breeding grounds must be considered broadly, and include not only the nesting site but also the feeding grounds, even when they are physically very different, because ecologically these conditions form a unit during the breeding season.

It is well known that when a given set of physical conditions are dominant, as in a dense conifer forest, a swamp or an extensive orchard, relatively few individuals and kinds of breeding birds are characteristic of such conditions, except in the case of those nesting in colonies. The field relations of these colonial and isolated breeders are quite different. It is also of importance to recall that abundance is a relative term, with a very different meaning in the case of seed-eating and predaceous species.

Bearing in mind these conditions, bird succession means a change from the dominance of certain species or associations to that of others. Thus in the beginning a slight change in abundance of a species may be noted, with a corresponding decrease in another; and this proportion may continue to change until the intruder becomes dominant and the rival form may disappear entirely. This process of change, as a rule, is not limited to a single species, but usually involves several or all of the members of the association, as when a dune invades a swamp and the swamp birds are completely replaced by those frequenting the sand dunes.

2. *Succession on Isle Royale.* With these preliminary considerations in mind, we will turn to the ecological succession of bird life upon Isle Royale, Lake Superior. The field work upon the island was carried on by a party from the University Museum of the University of Michigan, under the direction of the writer. Aside from succession, the general ecological relations of the birds were studied by Otto McCreary and Max M. Peet, and elsewhere detailed descriptions of the region and detailed notes will be published. The writer has based his main records of habitat preference upon their work. For this outline of succession only the primary features of the location need be given.

In the present treatment an attempt will be made to follow the genetic succession, at least in its broader outlines. Various qualifications and reservations have been made, and others will follow, so it is hoped that no confusion will be produced by this method of treatment.

Geographically, Isle Royale, Michigan, is an island in Lake Superior, near the North Shore, not far from Port Arthur, Ontario. The *topography* forms a part of an ancient peneplain of moderate relief, glaciated and with an abundance of elongated low ridges and valleys with numerous water basins. The *soil,* which is locally absent, is generally humic

or mixed in character, bordering and in the depressions; but is mineral, stony and residual elsewhere. The combined shore and beaches are extensive, largely stony and gravelly, and contain but little sand; much of the shore line is rocky and precipitous; many outlying islands. *Vegetation*, herbaceous in shallow inland waters and as a ground cover except where the shade is too dense, and upon rocks; shrubs on protected beaches, in more open places in the forest and in burns; the forest consists of Tamarack, Black Spruce and Arbor Vitæ in bogs; and elsewhere in mesophytic conditions of Balsam Fir, Arbor Vitæ, White and Yellow Birch, and rarely Sugar Maple. Upon the dry ridges, Jack Pine; and in burned areas, Aspen and Paper Birch. *Climate*, seasonal changes very pronounced; winters very long and cold, and summers short and cool; a relative humidity of about 80% in December and of about 70% in July (*cf.* Johnson, '07); a mean temperature for January 7.97° F.; and for July, 62.24° F. (Port Arthur data). Early, deep snows. *Predaceous* animals, as the Lynx, Marten, weasels, Red Squirrel and bats are directly in competition with the birds for food, or prey upon the birds.

The above environmental factors are dominant features and give us a general picture of the conditions, largely in terms of common experience. In the life of the birds, however, a complete reassortment and change of intensity in these factors occurs when they are combined as habitats. The surrounding lake, the numerous bays, small lakes and ponds compose the aquatic habitat and make it a characteristic feature. The very irregular and extensive shore line and limited beach area characterize the coastal border, while inland, excepting the main bodies of the few larger lakes, the encroachment of the bog vegetation upon the shores is such as to prevent an extensive development of sandy open beaches. The above mentioned habitats are open unforested areas; the remainder of the island, with the exceptions of the bare rocky ridges, the clearings and burned over areas, are fostered. Very extensive swamp forests abound in the elongate valleys and the borders of the water bodies, and are composed of Tamarack, Black Spruce and Arbor Vitæ. The mesophytic forest occurs on drained areas and is characterized by Balsam Fir, White Spruce and Paper Birch; the burned areas by second growths of aspens and Paper Birch. Then there are also influences which are exerted upon the bird life in general, as for example, migration. In this case, undoubtedly both external conditions and the habits and the behavior must be correlated. Another general and dominant influence should be reiterated here, and that is that all open areas tend to become invaded with vegetation and finally forested, whether they are lakes, ponds, bogs, rock openings on the ridges, burns or clearings. The mesophytic Balsam-spruce forest tends to monopolize *all* habitats, and gives a definiteness to all succession upon the island.

From a genetic standpoint the past and present dominance of the surrounding Lake must be recognized. This formerly stood at a level much above that of the highest ridges upon the island, as is clearly evidenced by the abandoned beaches on the north shore of Lake Superior. Such relations prove that Isle Royale was once a rocky reef in the lake, which, as the Lake level was lowered (it is quite unlikely that the

island has been materially elevated) became exposed as a wave-washed beach. These conditions are approximated to-day by the low outlying islands. The beach or shore is thus the *original* habitat upon Isle Royale, and in general, all others have been derived or developed from it. To discuss these as a truly genetic series would require that these be described *simultaneously*, as the differentiation took place. These habitats did not develop as isolated phenomena, but several developed at the same time, or abreast. Thus as soon as enough of the land surface had become exposed so that its inequalities began to have an influence, the ridges would be the parts best drained, and certain depressions would tend to accumulate the drainage. This process would lead to a simultaneous development or differentiation of the well, moderately, and poorly drained habitats. Almost all of the residual soil formed as the region was baseleveled was probably cleared away by the glaciers; or later, as the waves fell from the island, by the pounding of the waves. Thus the relative absence of a soil must characterize all habitats. At what period life first reached the island in post-Glacial time is not definitely known; but it is likely that the pioneer vegetation of lichens, mosses and low herbaceous vegetation reached it soon after its *exposure*. If the biota reached the island about the time of the formation of the Algonquin beach, which, roughly speaking, may have been at about the present elevation of 475 feet above the Lake surface, it has since spread upward and downward from that level. The composition of the initial societies is not liable to as much variation at the later ones. Thus if the Herring Gulls returned to the region at this early period of the exposure, they were probably the pioneer birds; but if only at a much later date, still other species might have accompanied them. While such variations as this may be expected, and due allowance must be made for them, yet there can be little reasonable doubt but that *water birds* and those frequenting *open places* tended to become the pioneers, and that later, with the development of a soil and forests, other associations of birds became established.

There are at least five important factors which enter into the composition of the past and present conditions which have moulded and are even now moulding the formation of the habitats upon Isle Royale. These five are:—*first*, past climatic changes; *second*, the local topography; *third*, the falling lake surface; *fourth*, dynamic tendency of the vegetation; and *fifth*, the habits and structure of the birds. With these guiding principles, let us now turn to certain details of the resultant succession.

a. The Aquatic Association and Habitat.

The expanse of Lake Superior, the irregular shore line producing coves, the inland water bodies and streams, together furnish an extensive and expansive area of habitat. The cutting of the Lake waves encroaches upon the land habitat, and the deposition by them elsewhere causes minor extensions of the land habitat (as at Rock Harbor where a sand spit furnishes a nesting site for a Kingfisher). Inland the encroachment of the vegetation tends to restrict the water areas, as the falling Lake level has, in the past, tended to increase the land habitat. These processes must be recognized in order to grasp the dynamic tendencies of the habitat.

The *characteristic* aquatic society is composed of the Herring Gull, Loon, American and Hooded Mergansers, and the Pied-billed Grebe; mainly fish eaters and scavangers. Other species, of greater inland tendencies, are attracted by the fish food, as the Eagle, Osprey and the Kingfisher. The Gulls show a decided preference for the great Lake, and the Loon for the inland waters. The presence of the Kingfisher was influenced by the harbor with its attendant sand banks and bars. As all these water bodies near Isle Royale freeze over in winter, the strictly aquatic birds must normally migrate to secure food. Of course none of these birds nest in the open waters, but on the island beaches (Gulls), near the mouths of streams, and inland in marshy places; but all, as a rule, nest near the water. The very young soon attend their parents, and are thus in the water at an age when many land birds are yet helpless in the nest, thus confirming their aquatic habits and habitat. During migrations many other species frequent this habitat.

Where Isle Royale now is, once rolled the open Lake; and it is not improbable that as the island appeared the Herring Gull was one of the first species to discover it. Such a bird might even reach the island under climatic conditions of the Ice Age, for the species now ranges far north along the shore of the Arctic Sea. A species of such extensive chronological and geographical range will tend to give much stability to succession. The present range of the Mergansers and the Loon is not so far north, and for this reason they may have arrived under milder climatic conditions. But if the island became exposed under mild post-Glacial conditions, all of these species may have arrived at much the same time. But even with the chances for such variations the general succession seems to have been initiated with the aquatic association as the pioneer society.

In following the genesis of the habitats and associations from this point onward, divergence and differentiation becomes so marked that it is impossible to develop all lines abreast. A linear treatment becomes necessary, and therefore certain general relations are liable to become obscured unless specifically mentioned in advance.

The aquatic and beach habitats possess a marked tendency toward a zonal arrangement. From the Superior beach the transition is through open or shrub zones into the climax forest. The topography of the island with its longitudinal ridges and valleys form a dominant factor in impressing this zonal structure upon the biotic associations. The series, —from the water, through the beach, open and shrub marginal zone, into the climax forest,—may be considered as the genetic vegetable succession. They change simultaneously and are due to the same general cause,—the falling Lake surface, which transforms the water area into beach, the beach into forest margin, and forest margin into the climax association. But as mentioned, it is manifestly impossible to discuss all these transitions at once, and each ecological unit must therefore receive separate genetic treatment.

This tension line or marginal zone between the Lake and the forest shows such a wonderful diversity and complexity in its conditions, that several plant and animal associations are formed within this zone. With its onward march there are simultaneous changes in several asso-

ciations which, while they will vary in their changes, yet all tend to converge in harmony with the dominant factors. These conditions migrate or radiate from the highest land. On the other hand, the inland marginal zones, which border the smaller water bodies, migrate inwardly; and being closed areas, tend to become extinct. This marginal zone, particularly beyond the upper beach, forms one of the most interesting and complex conditions found upon the island. It is not an ecological unit, but is composed of several of them. This is where most of the confusion arises in actual field work of habitat studies.

b. *The Shore and Marsh Association and Habitat.*

As the area of the islands expanded and the shore line was lengthened, the habitat for shore birds increased; but the steep and rocky shores were unfavorable for the development of beaches because loose rock, as tools for the waves, was limited in amount. The local character of the shingle and gravel to-day found in the various coves clearly indicates their local origin; and much the same conditions have obtained in the past. On account of these conditions, the sandy beaches are very conspicuously absent. The dynamic tendencies of the beach are those which cause the extension or restriction of the aquatic and beach habitats, supplemented by the drift which is tossed upon the shore. Where there is shallow water, and mud accumulates, favorable conditions are furnished for invertebrate food for birds. Inland, the numerous lakes, ponds and marshes furnish shore conditions which tend to become extinct through drainage or overgrowth of the vegetation, except in those parts of the larger lakes where wave action tends to scatter such accumulations as rapidly as formed, or to prevent its formation altogether.

Although observations on this subject are quite limited, yet it seems fairly safe to consider the Spotted and Solitary Sandpipers as characteristic birds of this association. Upon such a rocky coast, sandy and gravelly beaches are quite exceptional and are confined to protected coves. Additional diversity is produced where small streams enter these coves and produce deltas.

Little is gained by sharply segregating the marsh and shore birds, although the marsh birds show a preference for conditions better represented or correlated with topographically older coasts, protected and inland conditions. Attention should be directed, however, to the significant fact that successions initiated with such diversity will produce a variation in the composition of the associations. Also that so far as possible these variations should be considered comparatively and synthetically in reconstructing and anticipating successions.

The American Bittern, Lesser Yellow-legs, Swamp Sparrow and Marsh Hawk belong to this society of marsh birds. As in the case of the aquatic association, these birds generally nest in close proximity or entirely within these shore or marsh conditions. Still other species frequent this belt to feed, as it is an open area; but their presence is mainly conditioned by the adjacent shrubs or forest. The very limited number of species in the aquatic and shore associations is worthy of particular mention.

The Yellow-legs, Spotted Sandpiper, Bittern and Marsh Hawk range far to the north, even to the Barren Grounds, and thus suggest chances, as in the case of the aquatic association, of an early arrival and succession upon the island.

With the growth of the island, there has been a corresponding extension of the outer and inner shore habits, although the encroaching vegetation has had a marked tendency to restrict the area of the inland habitat. The dominant environmental influences in this habitat appear to be, 1, the physical character of the shore and beaches; 2, the dynamic forces of the water bodies and streams; 3, the encroachment of the vegetation; 4, the downward migration of the shore; and 5, the habits and structure of the birds.

As a general rule, we may say that the beach of the outer lake tends to be succeeded by either the bog or upland associations, and those inland by the bog association.

c. *Bog-forest Association and Habitat.*

As just stated the outer coast or an inland one may develop into a marsh or bog habitat or association. In the bog, the Tamarack, Black Spruce and Arbor Vitæ are the pioneer trees in transforming the open marsh into a forested one; while upon the outer shore the alders and aspens tend to precede the conifers as a general rule. From the bog forest the transition to the Balsam-White Spruce forest may be perfectly continuous, and thus there will be a series characterized by the dominant conifers. In places Arbor Vitæ may form the dominant swamp forest, but this is only a variation in the conifer dominance. With improved drainage or the accumulation of vegetable debris, these habitats become converted into the Balsam-spruce climax forest and hence the environmental dynamic tendency.

As the forest encroaches upon the open bogs the Tamarack, Black Spruce, Arbor Vitæ, Cassandra, Labrador Tea and alders are accompanied by birds characteristic of this early stage; such as the Red-breasted Nuthatch, Yellow-bellied Flycatcher, Golden-crowned Kinglet, Cedar Waxwing, Chickadee, Canada Jay, White-winged Crossbill. Where alders abound the conditions are favorable for the Redstart and the White-throated Sparrow. But later, as the bog conifer forest becomes continuous and dominant, the Waxwing, Redstart and White-throated Sparrows diminish in numbers and finally disappear. Still later, as the swamp becomes eliminated with the development of the climax forest, the Yellow-bellied Flycatcher will also become excluded.

This is perhaps the simplest succession from the water to the climax forest, via the bog forest. This series is very perfectly preserved in all stages and has an extensive range. The number of species in the association is rather large when compared with the preceding associations.

d. *Aspen-birch Association and Habitat.*

This series develops from the beach and the waves fall from the ridges or low rock surfaces and leave the bare expanses. As the rock disintegrates, decomposes, and humus accumulates, a soil is formed, mainly in depressions or at the bases of the ridges, and from these

it tends to encroach upon the open places with a zone of Jack Pine, aspens, or White Birches. These areas are largely strips along the crests of ridges or small park-like openings on rather level rock. In no case are these single areas large, so that the habitat is only extensive in the aggregate. With the presence of the open aspen and birch woods, the following society is likely to be characteristic:—Junco, Oven Bird, Red-eyed Vireo, Chipping Sparrow, White-throated Sparrow, Flicker, Cedar Waxwing, Wilson's Thrush and the Chickadee. As the deciduous trees are replaced by the open encroaching conifer forest, the Song Sparrow, the Nashville, Myrtle and Black-throated Green Warblers and Wilson's and Olive-backed Thrushes, which frequent the forest margins, increase in abundance. The Oven Bird has an extensive northern range from Labrador into the Yukon Valley and may well have been a very early pioneer upon the island as the aspens and birches were probably the first broad-leaved tree arrivals. From the above it is seen that this means an extensive variety, but as the dominance of the climax forest encroaches this number again becomes reduced.

The composition of the society varies somewhat, depending upon the surroundings, as proximity of the present shore or distance from it. Many of these openings are continuous with the present beach. It is not improbable that this was a prominent society whenever the waters fell rapidly from the island between rather stationary levels. This has been a society decidedly on the decline with the encroachment of the forest.

Probably this association varies considerably in its composition, and has done so in the past; but its main features are fairly constant. These variations seem likely, through the influence of openings produced by fires which, when extensive, may have caused a new equilibrium among those species frequenting openings.

The Burned Area Association.

This phase should perhaps be considered as supplementary to the aspen-birch association just considered. A fire brings about a reversal of conditions through the destruction of the forest, and in some cases, a part of the soil as well. As there are all degrees of extent and completeness in this process, there is a corresponding variation in the details of the resulting succession, at least in its early stages. It is only when there is a very complete destruction of the vegetation that the continuity with former occupancy is wholly broken.

The easily inflammable character of these conifers, even when in a green condition, makes it likely that natural causes, such as lightning or marsh gas (*cf.* Penhallow, '07), may have been influential. The proximity of the gas supply and the conifers is of interest as this may influence their liability to fire and thus to this sort of reversal of conditions. Thus liability to fires is rather characteristic of the region, and man's influence has tended merely to reinforce rather than to introduce this feature. Thus it seems probable that fires have been a factor in supplementing the natural park-like openings. In addition to the burned areas found upon Isle Royale, other limited open areas are due to cultivation and are kept open.

The birds characteristic of the more open situations are the Sharp-

tailed Grouse, Song and Chipping Sparrows, Flicker, and the Purple Finch. The Grouse is a Plains form, is near its eastern limit, and is perhaps a late arrival upon the island. The other species are wide ranging in the Canadian coniferous forests but are not of such northern range as the aquatic and shore associations. There is nothing in their range to suggest their arrival earlier than the forest association. Taking all the birds of the openings together, it is not improbable that they arrived at about the same time as those of the forests, but frequented different situations,—the forest kinds occupying the slopes and drier valleys, and the others the openings.

e. *The Climax Association or Formation and Habitat.*

The climax association should not be considered in such a way as to lead one to think that it is *distinct* from the other associations. It belongs to *all* of them as the end of their series under existing biotic and environmental conditions. Thus the aquatic association, through the bog conifers, is transformed into the Balsam-spruce association; and from the beach through the aspen-birch association again to the balsams and spruces. The climax association is the condition of adjustment toward which all societies move under the present conditions. For this reason the earlier stages, conditions and associations of the climax have been outlined in the preceding discussion.

In the dominant forest the dense shade prevents an extensive ground cover of herbaceous plants; and although Ground Hemlock is abundant locally, yet in places the forest floor is quite open and free from lower shrub growth. The remarkable preservation of trails or roads through such tracts shows clearly how slowly changes take place. Such a habitat must be relatively equable in its temperature and moisture relations.

Geographically speaking, the primary characteristic of the climax is its *relative stability*, due to a dominance or relative equilibrium produced by the severe environmental and biotic selection and adjustment throughout the process of succession.

At this point attention should be called to the fact that dominance is a resultant of an equilibrium produced by neutralizing or overcoming other forces and influences. We may think of the process of succession as a stream of forces whose development may be compared with the transformation of a drainage line,—such as, for example, that of a rivulet into a creek, and then into a river. The stream and the character of the ground mutually influence each other and the course followed is a resultant of the mutual adjustments. The stream is deflected by one condition and then another, just as succession varies with local conditions; yet the water continues to run down grade and seeks an equilibrium, and similarly, biotic succession continues on its course deflected here and there by local influences, yet forever tending toward a state of biotic equilibrium. The dominance of the climax society or formation, considered as a process rather than a product, has much in it that is analogous to the dominance produced by the process of base-leveling.

The characteristic birds of the climax forest are:—the Chickadee,

Golden-crowned Kinglet, Red-breasted Nuthatch, Canada Jay, Downy, Hairy, Arctic Three-toed and Pileated Woodpeckers, and the White-winged Crossbill. Here again the association becomes small in variety of species and comparable with the small society which must have been associated with the complete dominance of the Lake waters. Thus there has been a development of diversity from simplicity, with later a return to simplicity. To these birds of the forest should also be added those species of general distribution, as the Eagle, Swift, Swallows, etc., a class of birds whose predaceous, insect-feeding and wide ranging habits make them particularly difficult to properly associate. A careful study of this class of birds will be necessary before they can be satisfactorily correlated with their proper avian associations.

But let us not overlook the fact that even this dominance is only *relative,* for since the Ice Age even this *entire formation* has migrated northward, and a true succession has been produced with its attendant changes in the conditions and in the composition of the associations. Just as upon Isle Royale a definite dynamic trend was given to the complete environment by the falling Lake surface, so in the post-Glacial northward migration there was a northward migrating climate. These conditions determined that on the *north side* of this immense succession or migration habitats and associations were developed which are comparable to those attending the downward march of the Isle Royale beach; and even today, by passing from Isle Royale to the tree limit with its zone of aspens and birches, one may find representatives of the various kinds of associations which in all probability moved north, just as today in passing from the forest to the rocky beach balsams and spruce are encountered before the aspens and birch. If, however, this is only another case of convergence and not at bottom the same or a comparable process, we are then certainly far from an understanding of even the general nature of the problem.

3. *Internal Factors.* With the idea of succession, as exemplified by Isle Royale, let us turn to other factors which influence the internal relations of the birds within an association or society, because such relations are also necessary to an intelligent understanding of succession. Some of these general relations have been outlined, but certain others are needed which have been well expressed by Brewster ('06, p. 62-63): "Many if not most birds show a marked preference for breeding in certain regions, throughout which they are more or less evenly and generally distributed, but within which their numbers do not seem to increase beyond fixed maximum limits no matter how carefully the birds may be protected or how successful they may be in rearing their young * * * I have observed—as, indeed, who has not!—that few birds—excepting those which, like Swallows, Terns, Herons, and Gulls, are accustomed to nest in colonies—tolerate very near neighbors of their own species during the season of reproduction. At its beginning each pair takes possession of a definite tract of woodland, orchard, swamp or meadow, which the male is ever on the alert to defend against trespassers of his own kind and sex, although he often seems quite willing to share his domain with birds of other and perhaps closely related species. The extent of the area thus monopolized varies exceedingly with birds of different species. An apple orchard which affords

sufficient room for—let us say—two pairs of Yellow Warblers, two pairs of orioles, three or four pairs of Chippies and four or five pairs of Robins, seldom or never harbors more than a single pair of Kingbirds or crested Flycatchers. * * * As a rule, the species which roam over the most ground in the course of their daily wanderings claim and maintain the broadest preserves, while those of sedentary habits often content themselves with very modest freeholds. Whatever the extent of the domain, the birds who occupy it as a summer home evidently regard it as exclusively their own. The readiness and celerity with which trespassing birds are accustomed to retire when attacked or even merely threatened by the established tenants, has seemed to me to indicate that the claims of temporary ownership are respected by all right-minded birds. * * * In my opinion the desire for exclusive possession so conspicuously shown by the male, and often by him alone, is usually the direct result of *sexual jealousy*. This, as is natural, makes him intolerant, during the breeding season, of the near presence of rival males. If his concern were chiefly in respect to the food supply, it would be equally manifested at every season and towards all birds who subsist on the same food that he and his mate require—which is certainly not the case."

The tendency of pairs and species to *space themselves* and to become *relatively sedentary* is thus a characteristic condition in an association, and is an important element in an understanding of succession because it shows the internal organization and habit with which an invader or pioneer from another association has to contend. As Dixon ('97, p. 91) has pointed out, this spacing tendency is an important factor in the extension of range of species and is intimately related to the location of nesting sites. These facts clearly show that both these internal influences and the environmental ones must be distinguished if we wish to determine the relative influence of each and their bearing on succession. The above quotation from Brewster clearly shows that in general not only a greater number of birds can live in a given area, but also that they can live closer together, if they vary in kind. Then again, within the association there are marked differences in habitat preference. Thus in the forest there are those birds which nest in the trunks or among the topmost branches of the trees, or even upon the ground; and these are differences largely distinct from the spacing of the pairs of the same species. These influences must be recognized among the dominant influences within the association, and upon which much emphasis must be placed.

4. *Environmental Factors.* Then in addition to these internal factors, there are the dominant physical factors. In the following discussion primary emphasis will be placed upon succession as found in the Northeastern Biotic or Conifer Center, because successions at other centers with different biotic components and other dominant physical conditions must possess a certain amount of individuality, in addition to those features common to succession in general. The dominant biotic tendency or dynamic trend of this center, as a *resultant of all internal and environmental influences*, is for the conifer biotic association to *encroach upon all other societies and habitats and to become the dominant or universally distributed association.* Thus, in general, all

habitats produced by local influences tend to become transformed into the dominant biotic association or formation. In general also, small bodies of water are rapidly encroached upon by inwash, vegetation or drainage, and tend to become extinct and forested. All other openings, as the rocky ledges and ridges or burns, are encroached upon as soil accumulates or fires are prevented, and the forest biotic association spreads over the entire area.

From such relations it will be seen that our knowledge of the causes and conditions of succession must largely result from the study of these *local environments or habitats and their biotic succession,* because, where dominance is established the succession is almost completely obliterated. *Each minor habitat and society is to be looked upon as simply a stage, more or less temporary, in the onward wave toward the dominant or climax association.* Thus in the marshes, birch or aspen woods, rock openings and ponds may be "original" conditions which are becoming cumulatively transformed in the direction of the final dominance of the climax biotic type.

The relatively slow rate of change in many environmental processes and the relative stability of the climax biota,[1] is doubtless the basis for the current view that such conditions are relatively constant or fixed; but that change and not constancy is the normal and usual condition in nature is quite evident upon a moment's reflection. Almost every one notices these changes after an absence of a few years from a region. Thus intimacy tends to blind us to changes unless a *habit* of giving attention to them is deliberately cultivated. For this reason some find it almost impossible to recognize environmental changes or to comprehend their significance. It is therefore of practical value to recognize clearly under what conditions changes may be most readily perceived. Therefore the importance of the study of *local influences* is emphasized, and the necessity recognized of distinguishing the dominance of geographic and relatively stable conditions or formations as contrasted with those due to local and often relatively changeable conditions. Then among these changes we must distinguish those which are mere fluctuations and those which are indicative of the true progressive succession. This is mainly accomplished by attention to general relations and the subordination of minor details.

5. *Environmental and Associational Convergence.* At the present imperfect stage of ecological development, comparison must furnish us the most important and general clues to the processes of succession; and undoubtedly this method must long remain as our main guide on account of its comprehensive application and the magnitude of the problem to be solved. It is therefore desirable that the limitations of the method should be clearly borne in mind. It is often assumed that the implied successions of a given place are the same as those which have developed at that place in the evolution of the present climax. But as we positively know that *many different causes are able to produce the same or very similar results,* such conclusions must be received with due caution. That the dominant geographic conditions tend to override local influences seems very fairly established because *diverse local or original conditions are transformed into the climax or domi-*

[1] For the migrations of climax societies, *cf.* Adams, '05.

nant type. This clearly shows that in time diverse local influences have flowed into the general environmental trend or current and have become a part of it. There is thus a very strong *convergent* tendency. By convergence is meant the independent production of the same kind of association from diverse starting points or habitats and associations. Quite minor ecological units may show similar but temporary convergent tendencies in their succession. It is therefore not surprising that any marked environmental dominance will tend to produce similar or convergent results, even in local areas. Under such circumstances similar associations or societies may be independently and repeatedly formed by the selecting environmental influences, such as, for example, are found in the numerous small lakes scattered throughout the coniferous forests. This convergent phenomenon is certainly a fertile source of confusion throughout all phases of science. Perhaps the best guide through such a labyrinth will be to clearly bear in mind the relative value of general and local influences, and watch with an "eternal vigilance" for convergent results due to diverse causes. This convergent phenomenon is particularly liable to occur in the case of environments produced by reversible physical conditions. It should further be stated that a study of these problems from a genetic and dynamic point of view will aid in recognizing such results. Under such circumstances attention is primarily directed toward the dominant causes and conditions of change rather than to the stages, products, and results produced by them. Convergence thus viewed is the result of several causes and should be considered a product rather than a process. This same distinction may be made for all societies, associations and formations. *Convergent phenomena are thus particularly liable to confuse wherever products rather than genetic processes receive primary emphasis.*

6. *Succession and Environmental Evolution.* The relation of succession to general biological problems is very intimate. This opens up a very extensive field which is only mentioned to indicate its general relation to succession. The facts of succession and evolution must ever remain far in advance of our knowledge of their causes. If, however, one turns to the standard evolutionary treatises and searches for a discussion of the evolution of the environment, as correlated with animal evolution, only the most general, or the elementary and superficial phases, are as a rule discussed. To be sure, certain papers and treatises take up special phases of the problem, and the broadest phases are treated by the geologists; but none of them seem adequate as a comprehensive treatment of so important a subject. Succession, broadly and genetically considered (dynamic rather than static), is a phase of environmental evolution.

7. *The Relation of Succession to Organic Evolution.* Mention has been made of the relation of succession to environmental evolution, but its relation to the organic evolution of birds should also be indicated. The mutual relations of organic and environmental evolution have been and will continue to be the battleground of biological thought for an indefinite length of time. Here lies the tension line between the two main schools of biological interpretation.

One school maintains that all *causes* of evolution are *internal,* and

that the environment is only a *condition,* not a cause. From this point of view the fundamental causes are internal and therefore environmental conditions can only indirectly influence evolution through the weeding out of those forms not in harmony with the conditions; and hence it has a *selective* rather than an *originative* influence. From this point of view succession and environmental evolution can contribute nothing to the elucidation of the *causes* of organic evolution, though they may to an understanding of the selection produced by the succession of conditions in which organic evolution has taken and is taking place. In harmony with this point of view, succession, broadly treated, should furnish a fundamental method of treatment for the process of selection, and the detailed principles of its working. This would certainly be an important advance because natural selection has frequently been reproached for its indefinite methods and lack of definite treatment. Succession from this point of view is primarily related to the Darwinian factors of evolution. No doubt this is one reason why Darwin himself put such high value upon the study of ecological relations of animals, *i. e.,* their relation to their complete environment, or their struggle for existence.

If, however, all causes are internal and not directly subject to external influences, they must be beyond experimentation to a corresponding degree. Under such conditions evolution becomes a *descriptive* rather than a *causal* science, and all that investigation can do is to describe the succession of forms produced by these internal causes.

On the other hand the rival school maintains that both internal and external conditions may be real *causes* of organic evolution. This is thought to be brought about by the direct or indirect influence of the environment upon the germ cells, by environmental selection, or even by both combined. From such a point of view the environment may thus be either a *cause* or a *condition* of organic evolution, or both. From such a standpoint the evolution of the environment receives increased importance, as under such conditions organic and environmental evolution are causually related, and thus intimately correlated. Viewed thus, environmental evolution is more than the description of the succession of conditions, but may be explanatory as well.

The particularly significant feature is that environmental evolution and biotic succession are of great value and can contribute either to the causes or conditions, or to both, of evolutionary advancement.

VI. Some Principles of Succession.

By succession is meant the progressive change (= adjustment) in the composition of the associations at a given place. If a swamp becomes filled with dune sand, the birds characteristic of the swamp will be replaced by those of the dunes, and thus succession is initiated. But in addition to changes due to local influences there are those produced by very extensive or geographic influences, as in the case of a climatic change. Attention should also be directed to the fact, that biotic succession is only a particular phase of the general law of change which we see operating wherever a complex of forces are tending toward a condition of mutual adjustment. That succession is a process

which, from its very nature, must be as extensive as are the causes of change does not appear to have been clearly recognized by all students of biotic succession. For this reason there are certain principles of succession which are well established in other sciences, but which have not been applied to biotic succession. In human society, for example, there are many institutions whose formation, development and perpetuation clearly illustrate the laws of succession which also apply, not only to plants and animals, but to geologic phenomena as well. It is not at all surprising therefore that under these various guises their common features are easily overlooked and even denied by some students.

In the study of the animal environment some knowledge of the general principles of succession, not worked out in detail for birds but already well established elsewhere, ought to be suggestive and possibly valuable in the study of avian succession. Though such generalizations are primarily of a provisional and suggestive character, yet investigation should be stimulated rather than retarded by them. Such descriptive characteristics and principles are stated briefly in a form convenient for testing and criticism and should be useful as are criteria in the study of geographic origin. So far as known to the writer only two authors have attempted to formulate principles of biotic succession, and these have been limited to plants. The first is by the Danish ecologist Warming ('96, Oekologische Pflanzen Geographie, pp. 360-361), and the second by Clements ('05), whose treatment merits special attention. Cowles ('01) has done much to put the idea of succession upon a genetic basis. In the present outline only those features and principles are mentioned which are thought to be of a more or less general character, and those particularly applicable to animals. This list needs to be greatly prolonged, and the interrelations of these characteristics must be determined as well as their relative value and application to various ecological groups and in diverse regions. The following suggestions can only outline the problems involved. At this stage, differentiation is particularly desirable. Processes and products bear the same names and must be understood accordingly; thus the *processes of dominance* lead to the *product* dominance. Dynamically considered, the process is primary, but used in a structural sense such terms refer to products.

1. Starting with any given set of environmental conditions and organisms, these become a cause and condition of future changes. All changes are cumulative and form a continuous series or process.

2. No sharp line can be drawn between cause and conditions in succession as their relations are often reversible. A cause at one time may be a condition at another, and *vice versa.*

3. The formation or association itself must be considered as an essential part of the complete environment, and should be so understood when reference is made to the environment. cf. No. 1.

4. A given formation in its dominance tends to encroach upon all minor habitats and associations. These minor habitats tend to become cumulatively changed convergently toward the climax environment or formation. This is a process of eliminating diversity and thus establishing dominance.

5. Where complete environmental and biotic adjustment has taken

place, the dominance of the biotic formation is most complete. This may be considered a geographic or environmental optimum. This, in general, implies complete succession and the dominance of the climax formation.

6. From the standpoint of causes and processes, the succession of societies and formations is the expression or result of the environmental process moving toward an equilibrium.

7. The lack of a uniform rate of succession throughout large areas is the rule, on account of the slowness with which extreme conditions are transformed into those of the average.

8. The slowly changing extreme conditions tend to preserve many of the most important early stages of conditions and succession; hence the utility of these belated changes in validating succession as determined by the comparative method.

9. Other things being equal, the slower the succession the greater the chances for variation in the details and composition of the societies.

10. The formation or climax society is only the most conspicuous case of convergence, reached by all routes and successions, at a given environmental center.

11. The succession of societies within a formation is liable to be more stable in its main features than the composition of its societies. Probably the general features of such a succession most nearly approximate that which the region passed through in the development of the formation. Adams, '05, p. 67.

12. Formations of different geographic centers will vary in their *dominant dynamic tendencies*, yet open (unforested) formations will have certain features in common, as will also forest formations. Thus, not only will the compositions of the societies vary, but also the climax formations and their dynamic trends.

13. The stability of the climax environmental factors and their biotic formations is only relative. They may themselves migrate or change by a progressive succession in the direction of the dominant environmental trend. This migration involves a true succession, as is well illustrated by changes and successions attending the Glacial influences and the elevation of the Coastal Plain of the United States. (Cf. Adams, '05).

14. The stability of dominance is due to a complete biotic and environmental adjustment brought about by the repeated *selections* of the preceding succession and resulting in a "pure culture." Dominance may be likened to the static social condition of China or to a monopoly.

15. Succession is a form of complete or entire environmental selection, certain species or associations receiving an environmental approval while others are excluded. This is a particular and extensive form of natural selection. Successional selection in its broadest ecological aspect includes the evolution of the organisms, particularly as members of *associations* in their most intimate environment.

16. Any association not a climax is in unstable equilibrium and in a condition unfavorable to its permanence. The climax society is in a state of biotic and environmental equilibrium. (Cf. Warming, No. 6 and Clements V; also cf. No. 13, 14).

17. Widespread physically uniform conditions favor a dominant biotic formation. Climate may neutralize topographic diversity, or topography the climate. Baseleveling and other geological processes which favor the production of uniform conditions will favor dominance. (Adams, Amer. Nat., 35, p. 842).

18. From an evolutionary standpoint the ealier stages of succession are liable to be struggles with the physical environment; later, in the intermediate state of "storm and stress," the competition is most diverse and intense, and may thus be a fertile source of adaptive changes and individual adjustments, through severe selection; and finally in the stage of dominance, the competition is also biotic and physical, but under relatively simpler conditions. Permanence of new characters may be favored by habitat isolation and thus favor polytypic or divergent evolution.

19. In succession the adjustments and modifications of species may be accomplished by a change from one society to another as well as by individual modifications or adjustment within the society.

20 Pioneer invaders, except in social species, are generally isolated and increase progressively with dominance. Cf. Warming, No. 1.

21. Species and individuals in the early stages of succession or of societies are relatively few, increase in the intermediate stage, and are again reduced in number with dominance and in the climax society. Cf. Warming, No. 2. Clements VI. (3, 5).

22. The species of open (unforested) formations are only pioneer societies in forested formations and *vice versa*. Cf. Warming, No. 5.

23. The less sedentary species, those less inclined to regularly return to old nesting sites, and young birds tend to become pioneers and thus extend the breeding range. Cf. Warming No. 4. Dixon, '97, p. 91.

24. Pioneers generally come from near by and from similar conditions. Cf. Clements III, (3).

25. Extension of range takes place mainly at the unoccupied margin. This may mean unilateral or radiate extension. Cf. Clements V, (5).

26. The succession from the aquatic association to the forest is probably an ancient one. In this there is a general succession from the less to the more specialized kinds of birds. Cf. Warming No. 2; Clements VI (4).

VII. Some Advantages of a Knowledge of the Laws of Succession.

The study of succession implies a detailed knowledge of the field relations of birds, and as this has received so little attention as a subject of special study, it is perhaps worth while to mention briefly some of the practical and scientific advantages which we may reasonably expect will result from the development of this phase of investigation.

The current discussions of environments are generally very fragmentary and chaotic, and the careful study of bird habitats and succession will greatly improve this phase of ecology. Here is a field of study in need of distinct recognition as a subject worthy of detailed investigation, in addition to those lines already current. When once this field is developed, then and only then will it be possible to in-

telligently discuss the evolution of avian environments and to correlate them with the evolution of birds themselves. It is quite probable that one of the main conditions which prevents a more rapid advance along evolutionary lines is in a large measure due to the almost utter failure to analyze dynamically environmental complexes. Succession, studied in its broader aspects, should greatly aid in the formulation of the laws governing the "struggle for existence," which is frequently condemned for its indefinite character.

From another point of view there are very important reasons for urging extensive studies of this character at a relatively early date, because the encroachments of civilization, which by the destruction of the forests, the drainage of the land, irrigation, farming and grazing of the grasslands, are rapidly destroying original environmental conditions before they are studied ecologically. Much of Europe has already gone through this stage of demolition, and it is only to new and relatively unmodified countries that we can look for an adequate statement of these problems and their relations in their original and primarily evolutionary and developmental form. It is not improbable that the next generation may wonder why some subjects, the investigation of which might have been delayed, have received detailed attention, while others equally or perhaps even more important have been almost ignored and must forever remain unknown because of this neglect to secure the "vanishing data." (*Cf.* Haddon, '03.)

Such ecological studies may be expected to have a valuable reflex influence upon the naturalist himself. We may hope that the future revisor of a group of birds will consider a knowledge of the field relations of his specimens as an essential qualification, just as at the present time a large series of specimens is held necessary. Fifty years ago a limited series was considered no disqualification, just as to-day the lack of a knowledge of their ecological relations is not so considered. Perhaps our ideas of relative values must change. In this connection a statement from Tristram ('94, p. 472) is to the point:—"The closet systematist is very apt to overlook or take no count of habits, voice, modification and other features of life which have an important bearing on the modification of species. To take one instance, the short-toed lark (*Calandrella brachydactyla*) is spread over the countries bordering on the Mediterranean; but along with it, in Andalusia alone is found another species, *Cal. baetida,* of a rather darker color, and with the secondaries generally somewhat shorter. Without further knowledge than that obtained from a comparison of skins, it might be put down as an accidental variety. But the field naturalist soon recognizes it as a most distinct species. It has a different voice, a differently shaped nest; and, while the common species breeds in the plains, this one always resorts to the hills. The Spanish shepherds on the spot recognize their distinctness, and have a name for each species."

Many examples of similar character might be cited to show the scientific value of a knowledge of the environmental relations of birds, and a moment's reflection will show that the problem of succession is only a small part of the general problem of environmental relations of plants and animals. Attention has already been directed to the relation which this general subject bears to evolutionary problems.

It is not at all unlikely that succession is very closely related to some of the causes of bird migration, and that with advance in this subject much light would be thrown upon migration. Migration is doubtless another illustration of convergent phenomena. In all probability, migration has originated not only independently in very diverse kinds of birds, but perhaps repeatedly, from different causes, even in the same group. The causes of migration must be numerous, varying with different ecological groups, which appear to be the true natural units for study and comparison. Thus the comparative study of migrations of different kinds of associations, as formations and societies, should lead not only to a better understanding of the various associations, but should also contribute to the general subject of migration which seems to have shown a tendency toward stability in the current methods of study. It scarcely seems probable that with the diverse formations inhabited by birds, and with their ecological diversities there should be only a few causes of the phenomena.

To keep pace with successions animals must either adjust themselves, change their habitat, or migrate. From such relations it is evident that various supposed environmental responses must be *tested primarily within the association and environment to which the animal normally belongs.* To this class belongs protective coloration and allied phenomena. To be of fundamental value, the influence must have some permanence and this may be sought in the *dynamic* trend and dominant influences of different associations. It is difficult to conceive of other more reliable methods of approach to such problems.

In addition to the scientific value of this line of investigation, there are important economic applications of the laws of avian environment. This is particularly true of forestry and agriculture. The forestry problem is continually becoming more important, but the relation of bird life to forests and forest succession has received little attention. As agents for scattering seeds of trees and shrubs, birds are very important. Here is where the interests of the avian ecologist and forest ecologist overlap. The student of bird life will wish to know how a region is to be reforested, and what succession of bird life will attend the succession of the forest as reforestation progresses. On the other hand, the forester will wish to know how birds will aid or retard him in the process of reforestation. Then, in guarding or protecting the forest, what help can be secured from birds with regard to insect pests? These are only samples to show that here is a field which, as time advances, will become of more and more importance, and that these problems will eventually call for specially trained men to handle them.

In connection with forestry and agriculture we have quite exceptional conditions for extended experimental studies in bird succession as related to forest succession, crop rotation, etc. The relation of birds to agriculture appeals to a much larger number of people than does their relation to forestry. There are several reasons for this; first, because more persons are interested in farm and horticultural crops than in forests; and second, because birds are soon attracted in such large numbers by the food supply of grains and fruits which these crops so greatly increase, that the extensive destruction by birds readily attracts attention. And while we hear much of the great reduction of

certain species of birds in parts of the country, it is not at all improbable that with the destruction of the forests (which were dense and dominant and tended to *limit* the abundance of many species frequenting the open), and the increase of food in cultivated fields, there has been an increase in the total number of birds, even in spite of the great numbers killed by man.

But to the phase of succession with which we are primarily concerned, almost no attention has been given, in spite of its fundamental relation to crop rotation and the corresponding avian succession attending this. Indeed there seems to be a very decided need of a thorough investigation and discussion of the general principles underlying all these economic problems, that they may be brought into harmony with the advances made in some other phases of ecology.

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THE COLEOPTERA OF ISLE ROYALE, LAKE SUPERIOR, AND THEIR RELATION TO THE NORTH AMERICAN CENTERS OF DISPERSAL.

BY DR. CHAS. C. ADAMS.

1. *Introductory Note.*

The beetles secured in 1905 by the Museum expedition were collected during July and August by various members of the party. We are indebted to Prof. H. F. Wickham, of the University of Iowa, Iowa City, for the determination of most of the species; the remainder were determined by Mr. E. A. Schwarz, of the U. S. National Museum, through Dr. L. O. Howard and Mr. E. S. Titus. To these gentlemen we wish to express our appreciation for these favors. Mr. A. B. Wolcott has kindly furnished certain records of distribution, as indicated in the text.

The field notes and collections were largely made by Dr. H. A. Gleason; some were made by the writer; and specimens were also collected by B. F. Savey. The geographic range of all the species taken is given in some detail, as a basis for geographic conclusions. Time limitations have prevented a full discussion of these.

The geographic relations of the fauna have been discussed in more than customary fullness. The entire subject of the geographic relations of the North American beetle fauna had to be gone over; and as the work advanced, it became evident that a general account of these faunal relations was desirable from a standpoint somewhat different from that generally expressed. Undoubtedly many important papers and statements have been overlooked, so that it will be desirable for others to further extend this treatment of the subject.

Attention should also be called to the fact that in the past studies of the distribution of insects have been largely irrespective of their habitats, associations and such ecological relations. This has been one of the many defects of distributional studies, as it is of the present study. It is for this reason that an attempt is made to briefly discuss the habitat relations and successions of beetle associations. Life history, food habits and other ecological phases need detailed investigation and discussion so that all these phases can be related to the causes and conditions which affect distribution. The economic advantage of a knowledge of the laws of succession of beetle associations has largely been neglected, but ultimately must become one of the main general principles in much economic practice. This will probably become more conspicuous when forests assume a higher value, and the relation of beetles to reforestation, etc., demands careful attention.

II. *Notes on the Habitat Relations of Beetles.*

The beetles collected by our party were tabulated by Stations to determine if marked habitat preferences were evident. The tabulation shows that at most stations only a relatively few species were found. At those stations where the largest variety was found, as at our camps, the conditions were exceptional. The occurrence of the flowers of the Cow Parsnip attracted many species. It is quite evident that these flower frequenting species did not breed there, so that in a strict sense they do not belong to these open areas, as the breeding places of insects must furnish the only substantial basis for the determination of insect habitats. In many cases only provisional habitats can be assigned with our present incomplete knowledge of life histories. In many species the larval and adult habits are very different, particularly with regard to their food. For this reason error is very liable to occur and caution is necessary. In the present provisional discussion the haunts frequented by the adults have been primarily utilized. This is an unfortunate limitation, but it is hoped that this will not confuse the main feature of the problem.

On the Lake Superior beach (I, 1) the following 14 species were found: *Calosoma frigidum, Bembidium (five species), Rhantus binotatus, Anatis 15-punctata, Macropogon rufipes, Corymbites medianus, Podabrus diadema, Malthodes niger, Sericea vespertina* and *Leptura chrysocoma.* It is evident that some had been washed up by the waves (*Calosoma* and *Anatis*) while others normally frequent sandy beaches (*Bembidium*) or the beach pools (*Rhantus*), while still others were here because of the open character of the beach and the proximity of the forest. Hayward ('97, p. 37) says concerning the habitat of *Bembidium:* "Most of them are riparial in their habits, occurring under stones and refuse near the water's edge along streams, the shores of ponds, or on the seamoss, while a few occur almost anywhere."

The clearing about the Light-house (I, 7) had the greatest variety of beetles found at any station. It included 37 out of the 89 species found at all stations. There were several circumstances which combined to make this number large. The greater opportunity of those about camp to make collections; the season of the year (July); the presence of the Cow Parsnip in large numbers (which acted as insect traps, and upon which beetles congregated in such numbers that they were easily brushed into the cyanide bottles in large numbers); and the presence of logs, stumps, brush, etc. The flowers were a very conspicuous factor, and on these *Leptura chrysocoma* gathered in large numbers. The open space was favorable to the Carabids, the flowers, for the Coccinellids, Elaterids, Buprestids, *Trichias* and the Cerambycids. The two latter frequent also the logs and stumps. The wandering, tramp-like existence of these adult wood-boring beetles should not confuse one as to the true habitat of the immature stages which is in the forest. The surrounding forest was mainly composed of White or Paper Birch, Balsam and Spruce.

At the camp on Siskowit Bay (V, 3) somewhat similar conditions were found to those at the Light-house (I, 7), but there were fewer flowers, more cut timber, furnishing logs, stumps, brush; a log shack

was very thoroughly infested with beetles and their Hymenopterous parasites. The surrounding forest was largely White Spruce and Paper Birch. *Xylotrechus* was particularly abundant at this place.

Other open places, as those bordering the beach (V, 2) or the small openings on the ridges (I, 2), produced, in addition to the wandering flower feeders *Buprestis striata* and *Mordellestina scapularis*, a few Carabids, as *Harpalus megacephalus* and *Pterostichus femoralis*.

In the Balsam, White Spruce and White Birch forests (I, 3 and V, 4) the Staphylinids, *Grophoema*, *Bolctobius cincticollis*, the Erotylids, *Tritoma* and the Carabids, *Calathus* and *Blechrus*, are characteristic. The moist conditions which favor fleshy fungi show a marked influence. Here in the forest, of course, must also belong a great number of wood and bark boring beetles, which our limited collecting found assembled in the sunny openings on flowers.

Along the Desor trail (III, '04), through the hardwood forest of Yellow Birch, aspen and Sugar Maple, two other Staphylinids were found, *Quedius fulgidus* and *Tachinus memnoius* and the Scarabaeid *Geotrupes blackburnii*.

If now we turn to the lakes and bogs, a very different kind of beetle life is found. On the surface of Siskowit Lake (V, 6) were found *Gyrinus minutus* and *picipes* and in the water-lily margins of ponds and lakes were found (III, 5 and IV, 3) *Donacia proxima*, *cincticornis* and *Galerucella nymphaeae*. In the tamarack and arbor vitae swamps (I, 4, 6 and V, 5) the following species of water beetles were found: *Haliplus ruficollis*, *Hydroporus tristis*, *Agabus congener* and *Scutopterus hornii*.

These may seem very elementary and commonplace observations, but the principles which underlie the correlation of certain (even common) species and their environmental conditions are very generally ignored by students of local faunas, except for collecting purposes. To know the exact habitat of certain species in one locality does not by any means prove that the subject is exhausted for other localities. No general ecological treatment of our beetle fauna has been attempted, not even of the smaller groups, such as families or genera, or even for a local area. The nearest approach we have to such work is found in certain economic papers, devoted to insects affecting some particular plant. Here is an excellent field for investigation.

Before leaving the subject of habitats, attention should be called to certain publications which are of particular use in the study of the life histories of insects in these northern forests. The first is Packard's "Forest Insects," and the second is Felt's "Insects Affecting Park and Woodland Trees."

A few suggestions are added as to methods of ecological collecting which may aid similar surveys. When the time for a survey is limited some system of ecologic trapping will prove of great advantage. Thus for aquatic beetles traps, like those planned by Needham, may be very useful; and still others are needed for the ground fauna and those frequenting trees and shrubs. Sweeping and beating as usually practiced, while securing many species, certainly produce little ecological data. It may be suggested that systems of trapping may be devised which will contribute much valuable ecological information.

III. The Succession of Beetle Associations.

The subject of succession is a relatively new one in entomology. The only other paper treating of beetle succession known to the writer is that by Shelford ('07). Our points of view are very similar but have been independently conceived. Broadly speaking succession means the change, in time, of the insect life at any given habitat or place. Our aim is to note the changes in the composition of the beetles found *associated in a given breeding habitat or region.* The method is first to determine what species of beetles are associated or found together in the same habitat, and then to determine their mutual and environmental relations, so that their laws of change may be determined. Habitats and their associated insects have very rarely been considered as worthy subjects for special study. Even in very excellent local lists, but little attention is given to this subject. This is well exemplified by Wickham's Bayfield list. In one case he says: "A peat-bog of several acres in extent also proved very productive of peculiar species." But unfortunately he does not indicate the kinds.

In spite of the lack of a detailed study of the problem of beetle succession, however, certain general relations are apparent. We will only attempt an outline of the problem as found on Isle Royale. This involves an idea of the history of the island as the Lake formerly stood at a much higher level, which as it fell exposed Isle Royale. We are thus given, as a natural starting point, the Lake shore and beaches.

1. The Lake Shore and its Beetle Associations.

Topographically the shore is very diverse in its character, and all stages are to be found, from a cliff to a low rocky shore and on to the gravelly and sandy beach. When the shore lies at a low angle, so that beach pools are developed by the waves and rain, certain water beetles as *Rhantus binotatus* at Tonkin Bay (I, 1) and Scovill Point (IV, 1) find a habitat. Upon topographically older beaches, where gravel and sand have accumulated, various species of *Bembidium* are to be found, as previously listed. Such a sandy beach often contains a mixed lot of beetles, and may contain examples of a large number of species from all habitats, which have been tossed up by the waves. It is probable that many of these come from a considerable distance. Upon the upper parts of such a beach, where soil accumulates and annuals grow, certain flower beetles, as *Leptura* and *Trichias* are liable to be found feeding. In such a soil may be expected Carabids, as *Pterostichus femoralis* was found upon the heath beach (V, 2) on the south shore of the island.

The transition from the upper beach to the rock openings is often a gradual one; all stages of which were found preserved.

2. Rock Openings and Associated Beetles.

These park like rock openings and open oak ridges furnish a transition from the beach into the forest conditions. They are characterized by the absence of soil or the presence of only a shallow one, and by the reindeer moss and heath plant society. The shallow soil and low open veg-vegetation favors the continuation of some of the Carabids found upon

the upper beach, as *Pterostichus.* Under such conditions were found *P. femoralis* and *Harpalus megacephalus* (1, 2; V, 2). The flower feeders also continue to maintain their position, but the *Bembidiums* have largely been eliminated.

These open sunny spots, surrounded by dense shady forests, in their attractiveness for insects, remind one of electric lights where insects congregate in such vast numbers. As representative of these conditions the great variety of beetles found about the camps should be recalled.

3. Lake, Pond and Bog Habitats and Associations.

From the park-like rock openings let us turn to another series of open habitats: those which are initiated by inland water bodies. The water beetles to be found in the open lakes were not given special attention but there can be no doubt as to their existence in such places, but in general we may say that water beetles increase in number and kind nearer the margins and in shallow water. Here the *Gyrinids* (V, 63), *Donacia* (III, 5), and *Galerucella* (VI, 3) abound, while farther inland at the bog margins and in the bogs occur Haliplids and Hydrophilids, *Haliplus, Hydroporus, Agabus* and *Scutopterus* (I, 4, 6; V, 5). Even this brief series outlines the main features seen in the transition from the strictly open water conditions and species to those of the bog. But this succession may even be safely carried a step farther, as is clearly shown by an important observation by Wickham ('97, p. 126) at Bayfield, Wisconsin. He states that "The Water Beetles were not found in such abundance as I had hoped from a perusal of lists from northern localities, and of those named in the present report a great part were taken not in water but under moss in damp spots—a peculiarity which I have noted in some species of *Agabus* collected on a previous trip to Alaska." Under such conditions as this the bog association of water beetles may even be able to spread beyond the bogs and invade the forest, *a change of habitat* which has been recognized among plants but has been largely overlooked by students of animals. It is only by the detailed study of habitats that the significance of such facts can be understood and the peculiarities of succession determined for different regions.

There is thus seen to be a very perfect transition from the bog forest into that of the balsam and spruce, and the dominance of conifer trees clearly shows that the beetles frequenting such forests will be on the increase as the aquatic association of beetles declines in dominance. The methods and detailed order of this succession awaits investigation, but it is clearly dominated by the forest succession.

4. The Forests and Their Beetle Associations.

The gradual and perfect character of the transition from the bog to the balsam-spruce forest has just been indicated. This is paralleled by a corresponding transition from the park-like openings and the bare ridges to the forest. These habitats change as rapidly as soil, humus, and shade increase at the margins of the openings; and as shrubs and young trees encroach upon the open. Thus as the bogs fill up, and as the soil increases on the rock surfaces, both habitats tend to become trans-

formed toward and invaded by the balsam-spruce forest conditions and association. Here is a clearly defined convergent tendency, the exposed ridges and the water basins both tending to become forested. Corresponding with these environmental changes are corresponding ones in the beetles. The Carabids, as previously mentioned, continue in the humus from the rock openings as the water beetles may in the damp moss. As the vertical extent of the forest increases and the forest crown migrates upward, the intervening trunk, bark and branch habitat for beetles enlarges and the leaf eating inhabitants of the forest crown rise upward. This crown fauna retains, or rather continues some of the characteristics found at the marginal zone, with which it retains direct continuity. The marginal zone of trees is likely to be birches (yellow or white) or aspens, in the rock opening succession, and conifers in the bog series, a feature which influences the beetle fauna. With a dominance in the forest of Balsams, Paper Birch and White Spruce, the beetles (and many other insects as well) are likely to be much influenced, not only by the plant food, but also by the physical conditions associated with the forest. As one plant or forest society replaces another, the *unfavorable conditions* of the *declining* society may be expected to favor insect injury as it is well known that in general vigorous trees suffer less from such attacks than those which are defective. Under such circumstances as this insect injury may be a useful index of succession, as well as a factor hastening it. Under such circumstances the climax of insect abundance or dominance may lag behind the climax of the development of the plant society upon which it depends. Insects may also initiate a plant succession, through a period of extreme abundance by doing damage to the food plant, thus permitting the invasion of other forms. If, however, the hardwoods, the yellow birch-sugar maple forest, is the climax type, then the balsam-spruce-paper birch association will be succeeded by it in time; and a further change in the beetles may be expected. But here also, as in the coniferous forest, a dense forest stand appears to be unfavorable for the abundance and variety of beetles (as is generally the case with many other animals). This scarcity of beetle life in the dense forests of the Lake Superior region has been commented upon by LeConte ('50, p. 201) as follows: "The whole country being still almost in a primitive condition, the specimens are equally distributed throughout a large space; the woods will not therefore be found very productive to the collector. In fact nearly all the species were adjacent to small streams; or else were driven on shore, particularly on sand beaches, by the winds and waves after being drowned in the lake."

Throughout the preceding discussion the intimate relation of the beetles and the vegetation has been assumed. There seems to be a good reason for this. Ulke ('02, p. 3) has well expressed this dependence as follows: "Now, as about half of all the beetles depend upon plants for their food, the greater variety of food plants the larger we find the number of species of beetles." In this we also see why so few species (relatively) are found where a climax plant society has become dominant, because such societies are, as a rule, composed of but relatively few species. At the same time it is seen why at an intermediate

stage, with a diversified vegetation, we may expect the greatest variety of beetles. From such relations as these it follows that a knowledge of plant succession will furnish a very important basis for the study of beetle succession.

While these remarks have been primarily intended for beetles, it is equally evident that they have a much more extended application to other plant feeding insects and certain other invertebrates as well.

IV. The General Characteristics of the North American Beetle Fauna.

In attempting to form some idea of the general faunal affinities of the Isle Royale beetle fauna, the literature was searched for a general account of the distribution of North American beetles. As no recent comprehensive account of the subject could be found, various general statements and generalizations were compiled. On account of their scattered occurrence in the literature and their value and suggestiveness to students of other groups of insects, it has been thought desirable to assemble and publish them. An effort has been made to quote only the more important statements. Several of the older statements by LeConte, before he accepted the theory of evolution, are omitted. A similar selection has also been exercised in the case of some other writings. The main aim has been to bring together the most comprehensive generalizations which have been made upon our beetle fauna, so that they may have greater utility, further extension, and revision. Supplementary data from other groups of insects has largely been omitted, although this should be given due weight in a comprehensive study of this subject. The references should be consulted in connection with the compiled abstracts.

1. Compiled Generalizations on the Fauna.

Carpenter, W. L. 1875, pp. 539-542: "The principal and most interesting result obtained from the study of this collection, is the demonstration of the fact that the alpine insect-fauna of the Rocky Mountains, is nearly identical with that of Mount Washington (New Hampshire), Labrador, and Alaska; and that insects which are found upon mountains at great elevations will likely occur in a much higher latitude at a less elevation.

"Insect-life, with the exception of the grass-hoppers, is more abundant in the foot-hills than the plains near the foot of the mountains. An altitude of about seven thousand feet appeared to produce the greatest variety of species." p. 540.

Cockerell, T. D. A. 1893, pp. 305, 306, 309, 310-311, 312, 313-314, 315, 316, 317, 319-320-322.

"The insect fauna of the mid-alpine zone of Custer County [Colorado] presents some elements which are sufficiently diverse; but taken as a whole, it is a natural fauna, belonging to a well-defined region, and hence available for comparison with other like faunae. It is, indeed, truly characteristic of the mid-alpine, that besides its ordinary elements, it contains species coming up from the sub-alpine, and down from the high alpine; but although it thus happens that *Junonia coenia* and *Parnassius smintheus* have been taken in the same zone, it does not follow that either are truly characteristic of it, or that they belong to the same fauna. All faunal lists contain such excep-

tions or deviations from the average; but when, as in the case of Colorado as a whole, there is no uniformity about the range of the various species, and the majority do not occur throughout the territory, it is impossible to treat the region as containing a single fauna." p. 305.

"The mid-alpine zone, as I have defined it,* extends from about 6,500 feet to 10,000 feet. It is essentially the zone of oak-scrub (*Quercus undulata*) and quaking asp (*Populus tremuloides*). Its most characteristic conifer is *Pinus ponderosa* var. *scopulorum*, but with the high-alpine zone it shares *Picea engelmanni*, with the sub-alpine, *Pinus edulis*, and *Juniperus virginianus*." p. 306.

"Among the Coleoptera it will be noticed at once how many of the species are boreal extending to Canada (*sens. lat.*) and often to the New England States. The Southern element is but slight although distinct if looked for; and there is also a fair number of species endemic in the Rocky Mountains. The Tenebrionidae, characteristic of the Western prairies, are fairly numerous. The Coleopterous fauna, as a whole, is strikingly distinct from that of the Mississippi region and the Eastern States generally, except as regards the boreal element. Mr. Wickham has published a list of the beetles found in the vicinity of Iowa City, and on comparing it with the present list, I was astonished to find how few were the species common to both. This result is brought about in large measure, no doubt, by the different character of the forests—those of Iowa containing a great variety of deciduous trees, those of Colorado mainly conifers, with very few deciduous species. Thus, it happens that not one species of Cerambycidae is common to the Custer County and Iowa City lists, although six species are common to our district and the much more distant State of New Jersey." p. 309.

"The high-alpine zone in Custer County extends from 10,000 feet on the Sangre de Cristo range to summits of the mountains (Gibb's Peak, wrongly called Gibson Peak, 13,729 feet; Horn's Peak, 13,447 feet; Humboldt Peak, 14,041 feet, etc.). A list of the high-alpine species so far as observed, is given in "Can. Ent." 1890. Although the number of records is not great, they show that the high-alpine and mid-alpine zones are sufficiently distinct." p. 310.

"Of the high-alpine Coleoptera, 25 species are recorded, and a 26th may be added, namely, *Coccinella trifasciata* L., from near the Micawber Mine in October. It extends to Canada, Lapland, etc. Of these 26, seven genera are not mid-alpine, namely, *Orsodachna*, *Dichelonycha*, *Chrysobothris*, *Zeugophora*, *Athous*, *Dasytes* and *Glyptina*. Eleven of the species are wanting in the mid-alpine collections." p. 310.

"These statistics would undoubtedly be altered by further research, but I do not think they can be without significance. That the high-alpine and mid-alpine fauna are largely of different derivation seems to be proved by the large proportion of *generic* difference. Thus, 25 distinct species of Hymenoptera include no less than 16 genera; and eleven Coleoptera include eight genera. The high-alpine, therefore, is not, as regards its peculiar features, derived from the mid-alpine or lower; contrasting in this respect with the high-alpine of Ecuador, which is so derived.

"The affinities of the high-alpine not being with the mid-alpine, they could only be with the far North. Alberta being a suitable region for comparison, I wrote to Mr. Thomas E. Bean, asking him to tell me how many of my high-alpine species occurred with him. He most kindly replied, giving me the following interesting information:

"Of the Coleoptera, he finds at Laggan *Dolopius lateralis*, *Podabrus lateralis*, *Orsodachna atra*, *Cicindela longilabris*, *Adoxus vitis*, *Chrysobothris trinervia*, *Coccinella transversoguttata*, *Trichodes ornatus*, *Acmaeops pratensis* and *Mordella scutellaris*. He adds: "That is a good sprinkling concidering that I derive the facts from a small lot I sent Mr. Fletcher several years ago, presumably the commoner species.' * * * The timber line at Laggan is at 7,000 ft. p. 311.

"Thirty-six Coleoptera were found and identified in the sub-alpine zone, and of these twenty-two, or nearly two-thirds, were not found in the mid-alpine. These include the following eleven genera not found in the mid-alpine: *Pityophagus*, *Batyle*, *Ditylus*, *Badister*, *Serica*, *Diabrotica*, *Tomicus*, *Polyphylla*, *Euryomia*, *Listrus* and *Desmaris*. Of the thirty-six species, only one, *Hippodamia convergens*, was observed to range up to the high-alpine.

* See "Entomological News," 1892, p. 203.

"Thus, in both Coleoptera and Orthoptera, the difference between the two zones is seen to be very marked, not only as to species, but also as to genera, showing that we have to deal with distinct fauna. p. 312.

"So far as I am able to judge, the suppression of the central region is entirely justified, but I cannot agree as to the proposed Sonoran region. An analysis of the insects of the Colorado Rocky Mountains shows that the high-alpine and mid-alpine elements, although sufficiently distinct, are both essentially boreal. If we follow Dr. Merriam's arrangement, it appears that the high-alpine is truly boreal while the mid-alpine belongs to the transition region, containing a considerable number of strictly American types. The sub-alpine, on the other hand, is southern or Sonoran.

"Dr. Horn has kindly given me his opinion as follows: 'My ideas of the distribution of the Coleoptera in the mountainous region of Colorado, which is a good center of the Rocky Mountain chain are as follows: The high region seems to have been populated from the Canadian through the H. B. T. region. A collection made above 8,000 feet in Colorado is almost identical with one made in the Lake Superior region. The same fauna runs down to N. M. and Arizona, and again appears, mixed, of course, in the Mexican Mountains.

"'The sub-alpine region is one that continues from Washington to New Mexico, as shown by such striking forms as *Ergates*, *Melanophila miranda*, *Iphthimus serratus*, *Galeruca externa*, *Calosoma lunatum* in varieties.

"'The lower region, foot-hills, etc., is a mixture of New Mexico forms with those of the Eastern United States, with some peculiar forms allied more to the southern regions.

"'California is a peculiar region, and, in many respects, allied to Europe (in general). I think California supplies us with more species of genera peculiar to Europe than does the Eastern region.' (In litt., July 14, 1892.)

"According to the facts now recorded it seems that there is, firstly, a circumpolar and strictly boreal element; secondly, a boreal but modified or Canadian element; and thirdly, a southern element belonging to the arid portion of Dr. Merriam's Sonoran region. I do not think any distinct faunae except these can be recognized, and the central region accordingly falls. But there is, sprinkled among the ordinary types, a *distinct element of endemic species*, to which I shall refer later. There also seems to be a few surviving fragments of an ancient fauna, of which *Anthracopteryx* is a good example.

"There seems to be a small California element, but the species falling under this head are perhaps rather Southern than properly Californian. pp. 313-314.

"The resemblance between the Colorado fauna, and that of the Mississippi basin and further East, always, excepting the boreal element that comes from the North, is very slight indeed. The great plains to the east of the Rocky Mountains have been as much a barrier as the sea would have been. p. 314.

"*A Method for Defining Faunal Regions.* It appears from a consideration of what has been written on faunal regions, that it would be desirable if some rules could be laid down, so as to leave the matter less to the discretion of the individual writer. It would require a good deal of research to determine what rules could be laid down, that would work, but as regards insects, at all events, I have thought it possible that the following rule might answer for secondary faunal divisions:

"*Any two districts shall be regarded as in the same secondary faunal division if the number of species common to both exceeds the number of genera in common.* p. 315.

"*Equigeneric Areas.* For minor divisions, to be used in relation to particular groups, I have devised what may be termed equigeneric areas.

"*Equigeneric areas are areas throughout which the genera of the group under consideration are identical.*

"These areas are sometimes large, sometimes small. When two genera overlap, the region where they both occur, however small, makes a separate equgeneric area. This might be thought a disadvantage; but really, I believe it to be an advantage in the method, since it is important to recognize these intermediate or overlapping areas. p. 316.

"*Origin of the Rocky Mountain Fauna.* The numerous fossils of Colorado bear testimony to the fact that the region of the Rocky Mountains has in the past been peopled by a highly remarkable and numerous fauna. This fauna, however, does not appear to be ancestral to that of the present day. Nor has

the present fauna any special connection with that of the high regions to the far South—the Andes. In order to arrive at just conclusions, it will be needful to consider these points in some further detail.

"*Alpine Insects of the Andes.* The recently-published 'Supplementary Appendix' to Mr. Whymper's work on his travels amongst the Andes of Ecuador, containing an account of his captures, includes some very valuable information about the insects of high altitudes in that country. The late Mr. H. W. Bates has written the introduction, in which the following passages occur:

"'If there had been any distinct element of a North Temperate or South Temperate Coleopterous Fauna on the Ecuadorian Andes the collections he made, inexhaustive though they may be, would have shown some traces of it; but there are none. A few genera belonging to temperate latitudes, though not found in the tropical lowlands, do indeed occur, but they are forms of almost world-wide distribution in similar climates, and there is no representative of the numerous characteristic and common genera of the North or South. Even the Northern genera, more or less abundantly found on the Mexican highlands, are absent.

"'One feature of the fauna is of great interest. It is the occurrence of apterous species of genera which at lower levels are always winged.

"'It seems to me a fair deduction from the facts here set forth that no distinct traces of a migration during the lifetime of existing species, from North to South, or *vice versa*, along the Andes, have as yet been discovered, or are now likely to be discovered.'

"Going through the list of insects taken at high altitudes in Ecuador, the following points may be noted. There are four new species of *Pterostichus* from 12,000 feet upwards, but they represent a new subgenus. There is not a single *Amara* or *Harpalus*. pp. 317-318.

"*The Glacial Epoch.* It can readily be imagined that such a state of affairs [Prestwick's account of the Amer. Ice Age] would lead to the destruction of a large part of the fauna, the remainder either surviving along the northwest coast-line, or going southward to the Gulf States and Mexico. The eastern fauna, with which we are not now particularly concerned, would largely survive, owing to there being a considerable area of unglaciated territory available. This, indeed, has been the case. The Californian fauna would survive in part to the north, and also in lower California and the western coast region of Mexico. But the fauna of the central region would be almost annihilated, because the warm winds being cut off by the coast ranges, the country would become extremely cold, even far down into the higher lands of Mexico. The arid region where not actually glaciated would be a frozen desert, and the migration of the fauna southward would be far from easy.

"In the eastern province the species of the moist Northern States would find little difficulty in migrating southward into the equally moist Southern States. The isotherms would shift southward over moderately uniform country. In the central region, however, this would not be the case. There is no place available to the South, except the moister coast line, and the interior uplands, which latter were undoubtedly glaciated. The great plains between the Rocky Mountains and the Mississippi would have made an impassable barrier for most species, preventing migration in that direction.

"But, it may be urged, at *some* point to the southward the mountains or central uplands would cease to be glaciated, and why should not migration take place into the neotropical region. That it did *not* take place at all events beyond the isthmus, is evidenced by the facts above quoted from Mr. Whymper's 'Appendix;' and the reason of this no doubt is, that the isthmus itself was submerged, and all connection between North and South America cut off. This question of the submergence of the Isthmus of Panama has been fully discussed by various naturalists, and need not be enlarged upon here.

"It is impossible in the present paper to give more than this bare outline of the subject, but I believe the conclusion is justified, that the central region fauna was practically stamped out during the glacial epoch; and that the present fauna is derived from the boreal faunae which survived to the east and to the west, and the southern fauna which survived in Mexico. This view seems to be supported by a consideration of the present distribution of species, as well as by geological evidence. pp. 319-320.

"*Post-Glacial Developments.* Excepting the remnants of the ancient fauna,

all the strictly endemic element in the Rocky Mountains is of *post-glacial* origin—that is, according to the views here set forth. This means a good deal, if it is actually the case, as I believe. Under certain circumstances, species develop quickly, and we have, at least among insects and flowering plants, a great array of new species coming into existence. Such species are closely allied to species from which they sprang, and to each other, so as to give rise to much dispute as to their validity—as an example, one may cite the genus *Argynnis*, which has been very productive of post-glacial species in America. In such a case it matters little whether we term all these diverse forms true species, or subspecies or races,—but to lump them under a common name obscures the facts, and leads us to ignore one of the most interesting phenomena that are presented to a zoologist. pp. 320-321.

"*Species-Forming Areas.* It is well known that the genera commonly accepted are unequal in value, but most of those whose validity could not be questioned, are evidently of considerable antiquity.

"But the curious thing is, that these wide-ranging genera are not equally productive of species over their whole areas. p. 321.

"Among insects, *Argynnis* and *Colias*, and several genera of Noctuae, exhibit strong species-forming tendencies in the Western States of North America. *Catocala*, in the Eastern States, has a very strong species-forming area. And so on in many other instances which will occur to the reader. This phenomenon is a most remarkable one, since it affects chiefly old and almost cosmopolitan genera, and does not occur in the same districts in all the genera. Two cosmopolitan genera, as we have seen, may have their species-forming areas on opposite sides of the world. It would seem, indeed, as if there were causes at the bottom of it, that we do not yet understand." p. 322.

Fall, H. C. and *Cockerell, T. D. A.* 1907. pp. 150-151, 152-153: "Comparing the beetles of New Mexico with those of Colorado, one is struck by the large amount of difference in the lists. Colorado has not, of course, the important and characteristic Middle Sonoran element, but the higher elevations are continuous from north to south, and one would expect a practically identical fauna. Botanical investigations, however, have revealed striking differences in the plants of the northern and southern Rocky Mountains, and a degree of endemicity among those inhabiting the mountain ranges which is quite surprising. The oaks (*Quercus*) are abundant in New Mexico, and have a luxuriant development as far north as Manitou, Colorado, and even beyond. But at Boulder, and north of Denver, generally, they are totally absent. On the western slope they go farther north, and one species just enters Wyoming; but there are none at all in Wyoming, with this exception, and none in Montana. This alone would explain the northward limitations to the distribution of the numerous species of Coleoptera which are attached to the oak, and various similar cases could be cited. It appears probable that the oaks were driven south during the glacial period, and owing to the unsuitability of their seed for being carried great distances, have been unable to recover their lost ground. Under these circumstances, the ample powers of flight of certain of the oak feeding beetles are of no service for promoting migration northward of the slowly moving line of oaks. pp. 150-151.

"It will be noted that New Mexico shows a greater proportion of non-Colorado genera than species; or, in other words, the species found in New Mexico but not in Colorado are more likely to be of non-Colorado genera than in the reverse case. This is explained by the fact that the desert fauna in nearly all groups is rich in peculiar genera, but these are represented so far up as New Mexico by comparatively few species. On the other hand, the boreal fauna, so strongly developed in Colorado, is largely characterized by the abundance of species of circumpolar genera.

"In Colorado the eastern plains region has been little searched for beetles, and the corresponding region of New Mexico is also poorly known. There is no doubt that the plains will furnish many species additional to the lists, and most of these will doubtless be common to both. The following are characteristic eastern species which are known to reach New Mexico, but have not yet been found in Colorado: *Scarites subterraneus*, *Clivina bipustulata*, *Clivina ferrea*, *Aspidoglossa subangulata*, *Panagaeus fasciatus*, *Tachys xanthopus*, *Pterostichus sayi*, *Dynastes tityus*, *Anomala undulata*, *Alindria teres*.

"The New Mexico list contains over 135 species, indicating that the eastern

fauna is really crossing the plains to some extent, and not only reaching us by way of the northern mountains. There are strong reasons for believing that a considerable part of this migration is recent, and has been assisted involuntarily by man. This affords, of course, a strong argument in favor of the speedy exploration of western regions, in order that their original fauna may be ascertained before it is unduly contaminated by introduced forms. Fortunately for the naturalists, the desert will not quickly or easily accommodate alien elements, but it is quite otherwise in more ordinary localities; and as Perkins has shown in the Hawaiian Islands the result may be destruction as well as confusion.

"The number of species common to New Mexico and Southern California, but not known from Colorado, is over 160, indicating a wide-spread southwestern fauna; but in general, the species of the Southern California coast region are not those of the Rocky Mountains.

"We find over 30 names of New Mexico species listed from the Lower Rio Grande, but not in the Colorado, Southern California or District of Columbia lists. Such for example: *Cincindela circumpicta*, *Cindela severa*, *Dyschirius terminalis*, *Philophuga viridicollis*, *Helluomorpha ferruginea*, *Oodes cupraeus*, *Ischiodontus ferreus*, *Ludius texanus*, *Agrilus addendus*, *Mastinocerus texanus*.

"The following are examples of characteristic southern genera which reach New Mexico, but do not enter Colorado: *Thalpius*, *Hololepta*, *Sandalus*, *Thrincopyge*, *Lycus*, *Plusiotis*, *Aphonides*, *Strategus*, *Allorhina*, *Derobrachus*, *Tylosis*, *Dendrobias*.

"Because of the conspicuous place which these southern genera occupy in the fauna, an entomologist arriving from the north or east is very likely to assume that the Middle Sonoran of New Mexico contains precisely the same elements as the Lower Sonoran of Arizona just as it has been assumed that Florida is typically West Indian, because its numerous West Indian genera attract attention, and the *absence* of innumerable West Indian types is not so readily observed." pp. 151-153.

Hamilton. '94 a. pp. 408-415. Cf. also Fauvel '89. Hamilton gives the following lists of species indicative as to their nativity:

1. Species equally native in North America and in northern Asia not yet observed as occurring in Europe—49 species.
2. Species native in North America and Northern Asia occurring in Europe—277 species.
3. Species native in North America and Europe not at present known to occur in northern Asia—50 species.
4. Species probably introduced into North America now acclimated occurring in Europe, and those marked with a * likewise in Asia. Many of these are cosmopolite, or becoming so, through commerce—216 species.
5. Species cosmopolite or subcosmopolite.

Horn, G. H. 1872. pp. 383-384. "As is well known to all collectors, various species of *Eleodes* occur in great numbers in all parts of the west of our continent, and the species themselves occur over a wide range of territory, and are not limited, as might be inferred from their apterous condition, to regions of small extent. As we pass from east to west over a given line, we find variations of average temperature, and of course great differences in altitude. These two causes, combined with, of course, the botanical changes, have tended to produce variations from a given type to a greater or less extent. *Eleodes obscura* Say affords a beautiful illustration of the extent to which this divergence may be carried. As a general rule I find, not only in *Eleodes*, but also in many other genera, that the higher the elevation or the colder the climate, the rougher and more deeply sculptured is the species. The smoother forms of *E. obscura* may therefore be expected in the southern regions in which it occurs; for example, var. *dispersa* is New Mexican, elytra with scarcely any traces of striae; var. *obscura*, elytra distinctly sulcate, but not deeply, is from Colorado and Southern Idaho. As we advance to the west the elytra are more deeply sulcate, as in var. *arata*, while var. *sulcipennis*, from nearer the Pacific Coast, has deeply sulcate elytra, with very convex interspaces. The same variation of sculpture occurs in *Calosoma luxatum*, Say, which starts in Colorado with comparatively smooth elytra, until in Vancouver we find the elytra covered with lines of granular elevations, forming the variety known as *C. pemelioides*, Walker. The two extremes of each series above noted appear to differ widely

from each other, and to be entitled to rank as a distinct species. In the foregoing remarks reference only has been made to variations within specific limits. The same law appears to hold between different species. In the genus *Omus* the most roughly sculptured species occurs in Washington Territory, (*O. Dejeanii* Reiche) and the smoothest (*O. laevis*, Horn) from near Visolia, California. The object of the preceding remarks is to explain what appears to be a law of variation for our western slope, and thus cause the unnecessary multiplication of species, founded on slight characters, to be avoided.

"Species everywhere in our fauna appear to be distributed on lines of country presenting as nearly as possible similar meteorologic conditions. Thus many Oregon forms extend southward into California, gradually seeking a higher mountain habitat as the region becomes warmer. Two species illustrate this—*Tragosoma Harrisii* and *Phrygan-ophilus collaris*. Both extend their habitat from Maine to California following the cooler regions westward from Maine through the Canada and Red River region, thence northward nearly to Sitka. From the latter point southward to Oregon both occur at ordinary level, and rising as a more southern region is reached until at the latitude of Visalia they occur only a short distance below the snow-line, at an altitude of from ten to twelve thousand feet. p. 383.

"As might be expected each new region visited yields new *Meloidae* of the genera *Epicauta* and *Lytta;* in fact, each species of *Astragalus* has its peculiar *Lytta;* and whenever any of that genus of plants is found in flower, an accompanying visitant may always be looked for." p. 384.

LeConte, J. L. 1850. pp. 239-239*, 240*: "First, the entire absence [in Lake Superior region] of all those groups which are peculiar to the American continent. Thus, there is no Dicaelus, no Pasimachus among the Carabica; the Brachelytra are represented only by forms common to both continents. Among the Buprestidae is no Brachys; in the Scarabaeidae, the American groups (except Dichelonycha) are completely unrepresented; in brief, there is scarcely a genus enumerated which has not its representative in the Old World. p. 239.

"Secondly, the deficiency caused by the disappearance of characteristic forms, is obviated by a large increase of the members of genera feebly represented in the more temperate regions, and also by the introduction of many genera heretofore regarded as confined to the northern part of Europe and Asia. Among these latter are many species which can be distinguished from their foreign analogues only by the most careful examination. p. 239.*

"When a species in one district is paralleled by another in a different region so closely allied that upon a superficial glance they would be regarded as the same. These are called *analogous species;* e. g., the Olisthaeri, Spondyli, Bembidia, Helophori, etc., etc., of the preceding catalogue, as compared with European species.

"Where several species in one region are represented by several others of the same genus, which perform a similar part in the economy of nature, without, however, displaying any further affinity to each other. These are called *equivalent species;* e. g., most of the species of Cicindela, Brachinus, Clytus, Donacia, etc., of America, as compared with those of the eastern world. p. 239.*

"Notwithstanding this approximation to a uniform, subarctic standard, we still find in these boreal regions, a prevailing character of North American fauna—the extreme paucity of Curculionidae. The Donaciae too, although numerous, do not afford any prominent parellelism." p. 240*.

LeConte, J. L. 1851. pp. 249-250, 251, 252, 253-254. "The first fact observed by the collector [in California], is the very small number of species which can be obtained at any single locality. Day after day he meets with a continual repetition of a few common forms, with an occasional admixture of rare species; so that at the end of two or three months a single locality will have furnished him with about 200 species of Coleoptera, and a rather less number of other orders. It will be here remembered that the contrary is true of the eastern part of the continent, where each locality furnishes a large number of species, extending over a large area, and represented by comparatively few individuals.

"On removing to another locality, the same thing is again observed, with this difference: the species of the first place, even the most abundant, are replaced by others, many of which are true representative species, approaching as closely as those of Eastern America and Europe; while others belong peculiarly to their

own district, and are without any representatives in the other parts of the country. pp. 249-250.

"It must be observed that the localities east of the Sierra (Vallecitas, Colorado and Gila) show more resemblance in their productions than the maritime regions of California: the desert nature of the country undoubtedly produces this effect, by presenting conditions unfavorable to animal life; yet even in this uniformly sterile tract, great differences are observed among the smaller species which abound only in moist places. p. 250.

"The first point worthy of notice in this list is the extremely small number [compared with Europe] of Scarabaei, Elateridae and Longicornia: this might have been predicted, as these insects derive their food for the most part from large plants. The Curculionidae and Chrysomelidae are not in the same proportion as in the more wooded countries. The saprophagous Coleoptera, with the exception of Histeridae, are almost wanting: and these latter are not in larger proportion than with us. Thus the only effect, so far as observed, is the paucity of species in tribes for which the country affords but little food. The Staphylini and Carabica bear the same proportion to the whole, that they do with us; while the deficiency caused by the small representation of the tribes mentioned above, is made up almost entirely by the Tenebrionidae, which, as is well known, are but slightly developed in Eastern America. The Malachidae are also in larger proportion than in other parts of the continent." p. 251.

"The Tenebrionidae, from being the group most characteristic of the country, might be supposed capable of giving us the most certain data with regard to the law of distribution. The great majority of the genera of this tribe are apterous; and of those which are not apterous, all the genera found in California are cosmopolitan (Phaleria, Platydema, Helops, Uloma, Tenebrio, Upis, etc.), except Blapstinus, which again occurs in tropical America. Of the apterous genera, only three are found in eastern temperate America: two of these are peculiar, and one (Nosoderma) which exists in California is also found in Brazil. Of this group, there are in California about 28 genera, of which 5 or 6 extend into the tropics.

"The Histeridae, though not in undue proportion, exhibit a peculiarity: they nearly all belong to the genus Saprinus, which, in Eastern America and Europe, forms scarcely one-fourth of the group.

"Thus the only manner in which the insect fauna of California approaches that of Europe, is in the great abundance of apterous Tenebrionidae. But in this respect it does not differ from a large part of South America and by the very form of these Tenebrionidae, which bear no resemblance at all to those of Europe, the greater relation of the Californian fauna to that of the rest of America is clearly proved. It will be seen, too, that the resemblance to European forms in the other tribes is only indirect, proceeding solely from universal or zonal forms, while the greater relation is again with the rest of America. It will moreover be seen, that while the stronger relation of the fauna is continental, yet a sufficient number of individual peculiarities are introduced to prove that it constitutes a system of its own, bearing no relation to that of Eastern America, except the slight continental resemblance proceeding indirectly through the tropics. pp. 251-252.

"The principles shown by the preceding analysis may be expressed briefly as follows:

1. California constitutes a peculiar zoological district, with sufficient relation to the other districts of America to prove that it belongs to the same continental system.

2. This zoological district is divided into several sharply defined sub-districts, having a very close resemblance to each other.

As the same mode of distribution obtains in the group of islands adjacent to the western coast of America, we are led to believe,

3. That the local distribution of a small number of species is the characteristic of the eastern Pacific region, as the extensive distribution of a large number is the prevailing feature of the Atlantic.

4. The genera occurring in, but not peculiar to, this district, belong to two classes: either they occur on the Atlantic slope of both continents, or they are peculiar to America, and are also found within the tropics." pp. 253-254.

1859. pp. III-V. "Before proceeding to consider the special material used in the preparation of this memoir, it will be proper to give a short sketch of the

general results thus far obtained regarding the geographical distribution of Coleopterous insects in the territory of our republic.

"The whole region of the United States is divided by meridional or nearly meridional lines into three, or perhaps four, great zoological districts, distinguished each by numerous peculiar genera and species, which, with but few exceptions, do not extend into the contiguous districts. The eastern one of these extends from the Atlantic Ocean to the arid prairies on the west of Iowa, Missouri, and Arkansas, thus embracing (for convenience merely) a narrow strip near the sea-coast of Texas. This narrow strip, however, belongs more properly to the eastern province of the tropical zoological district of Mexico.

"The central district extends from the western limit of the eastern district, perhaps to the mass of the Sierra Nevada of California, including Kansas, Nebraska, Utah, New Mexico, Arizona, and Texas. Except Arizona, the entomological fauna of the portion of this district west of the Rocky Mountains, and in fact that of the mountain region proper, is *entirely* unknown; and it is very probable that the region does in reality constitute two districts bounded by the Rocky Mountains, and southern continuation thereof.

"The western district is the maritime slope of the continent to the Pacific, and thus includes California, Oregon, and Washington territories.

"These great districts are divided into a number of provinces, of unequal size, and which are limited by changes in climate, and therefore sometimes distinctly, sometimes vaguely defined.

"The Atlantic district may be divided into: 1, a northern province, including Maine, Eastern Canada, Nova Scotia, Newfoundland, etc., and extending westwardly from Lake Superior to Lake Winnipeg and Western Canada, which fades insensibly into the great Arctic district; 2, a middle province, limited westwardly by the Appalachian chain, and extending to Southern Virginia; 3, a western province, including Minnesota and the States of the valley of the Mississippi, as far as the State of that name; 4, a southern province, including the States south of Virginia and Kentucky; 5, a subtropical province, including the point of the peninsula of Florida; 6, a subtropical province, including the sea-coast of Texas.

"The Central district, as far as known, may be thus divided: 1, a northern province, comprising the regions north of the Missouri, the plains of the Saskatchewan, etc.; 2, a middle eastern province, divided into two subprovinces, including: a, Kansas, and Nebraska; b, northeastern New Mexico; 3, a southeastern province, including Texas, with the exception of province six of the Atlantic district; 4, a southwestern province, including the upper part of the valley of the Gila; and 5, a south-southwestern province, including the lower Gila and Colorado. The unexplored portions of this district will indicate middle western, and northwestern provinces, or perhaps the necessity of constituting with them and the southwestern province a district to be called the Interior district.

"The Pacific district may be divided as follows: 1, a hyperborean province, consisting of Sitka and the neighborhood; 2, a northern province, including Eastern Oregon and Washington; 3, a middle province, including California, probably as far south as Santa Barbara; 4, a southern province, including California from Santa Barbara to San Diego, extending to the crest of the Sierra. Southern, or lower California is also, perhaps only in part, a province of this district;* but, as yet, no collections of magnitude have been received therefrom. Other provinces will, from the peculiar method of distribution of species in that portion of America, be defined when more full collections are made, but at present cannot be indicated.

"At the north, the Atlantic and Central districts seem to merge imperceptibly together, about the valley of the Athabasca, and Winnipeg rivers, and finally to disappear in the limited Arctic fauna; the hyperborean province of the Pacific district also fares into this Arctic fauna, without, however, losing itself so perfectly in the northern provinces of the other districts. We have thus evidence that the American Arctic district may be divided into two provinces, an eastern and a western.

*"A few species, collected by John Xantus, Esq., at Cape San Lucas, though all new, indicate a greater resemblance to the fauna of the lower Colorado, than to that of maritime California; this province may therefore be found eventually to belong to the interior district."

"At the south, the Atlantic district merges through Florida into the Caribbean tropical province, and through maritime Texas into the Mexican lower eastern province. In the same direction the Central district merges into the Mexican upper or central province, and the Interior district, towards the Gulf of California, into the Mexican western province. Regarding the southern affiliations of the Pacific district we know absolutely nothing; scarcely a single species found at San Diego had been found in Mexico.

"The method of distribution of species in the Atlantic and Pacific districts, as already observed by me in various memoirs, is entirely different. In the Atlantic district, a large number of species are distributed over a large extent of country; many species are of rare occurrence, and in passing over a distance of several hundred miles, but small variation will be found in the species obtained. In the Pacific district, a small number of species are confined to a small region of country; most species occur in considerable numbers, and in travelling even one hundred miles, it is found that the most abundant species are replaced by others, in many instances very similar to them; these small centers of distribution can be limited only after careful collections have been made at a great number of localities, and it is to be hoped that this very interesting and important subject of investigation may soon receive proper attention from the lovers of science on our Pacific shores.

"In the Central district, consisting, as it does to a very large extent, of deserts, the distribution seems to be of a moderate number of species over a large extent of country, with a considerable admixture of local species; such at least seems to be the result of observations in Kansas, Upper Texas, and Arizona." pp. III-V.

1860. pp. 2-4. "The distribution of species in the northern part of the region which furnishes the materials for this report [Pacific R. R. Report], presents no remarkable phenomenon. As in other northern lands, certain tribes like Adephaga, Staphylinidae, and Elateridae assume a greater predominance in the fauna, from the fading out of the groups more characteristic of warmer climates, while a greater number of species are found common to both continents. Of these latter, about one-half are found on the Atlantic slope of America, while the other half have not yet occurred there.

"The number of species occurring on both sides of America is also largely increased in these northern regions, but with the exception of *Epiphanis cornutus* and *Priognathus monilicornis*, the genera of such species are distributed on both continents.

"On proceeding southwards to Oregon (and Washington Territory, which is, for purposes of convenience, always included when Oregon is referred to in these pages), similar phenomena may be observed, though on a diminished scale. The species of the eastern continent, not found on the Atlantic slope of America, have entirely vanished, and of the species common to both sides of both continents, but four remain. The number of species common to the Atlantic and Pacific slopes of America has greatly diminished, and among them *Haplochile pygmaea, Ligyrus gibbosus, Alaus myops*, and *Microrhopala vittata* are the only representatives of America genera.

"Finally reaching California, the species common to the two continents are reduced to *Silpha lapponica* and *Dermestes vulpinus*, the species common to Atlantic and Pacific America have not diminished absolutely in number, but from the more complete and copious fauna known to their relative proportion is much lessened. Among them, however, are found but few which extend their range to the Atlantic States proper, while the greater proportion are not found east of Kansas. Of American genera, *Amblychila cylindriformis, Lachnophorus elegantulus*, and *Eurmetopon atrum* are found in Kansas, or New Mexico, while *Ligyrus gibbosus* and two species of *Diabrotica* also extend to the Atlantic."

"In Russian America the genera seems to follow to a certain extent the course already pointed out of the species, that is: the genera common to both continents have a much greater relative proportion, and among them a by no means insignificant part have not yet been found in Atlantic America; but as some of them are characteristic of high northern latitudes, there is reason to believe that the number will be reduced by more thorough explorations in Labrador, Newfoundland, and the regions near Hudson's Bay.

"Of genera confined to America, but six or seven occur in Russian America; of

these but three, Pristodactyla, Epiphanis, and Priognathus, have been detected on the Atlantic slope. Pristodactyla might, indeed, be for the present excluded from the list of peculiar American genera, for two reasons; 1, a certain number of species classed by Dejean, with Agonum, and remarkable for having but two dorsal punctures, are in reality Pristodactylae, and until the species of Siberia are thoroughly revised, we are warranted in supposing that some of them may also be included; but, 2, because the distinctions between Calathus and Pristodactyla, as observed by Lacordaire, are hardly sufficient to warrant the retention of the latter genus.

"In Oregon the eastern genera, not found in the Atlantic States, have diminished in number, but among them occurs Callisthenes, which is found in Kansas. The number of American genera has largely increased, even with our limited collections; of them 14 are found in the Atlantic States, 2 in Kansas, while 8 are peculiar to Pacific America; of the 14 found in the Atlantic States, Haplochile, Dichelonycha, Anelastes, and Alaus are the only ones not found within the tropics.

"In California the genera of the eastern continent have increased absolutely, from more extensive collections, over those found in Oregon, but do not attain the same relative proportion as those found in Russian Americá; among them is one, Tryssus, a genus heretofore known only from Madagascar, and is thus far the sole representative of the tribe of Scarabaeidae, to which it belongs on this continent.

"The number of American genera has greatly increased, partly by the addition of genera found within the tropics, and partly by the introduction of a few peculiar genera; the most remarkable addition, however, is that of eighteen genera of Tenebrionidae, of which but two, Nosoderma and Blapstinus, extend into the Atlantic States, while only four others extend into Kansas or New Mexico. The genera found in the Atlantic States, and not in the tropics, are Thalpius, Axinopalpus, Dichelonycha, Anelastes, Perothops, and Melanactes.

"Another fact of great interest is the distribution of species within narrow limits observed in California. I am not able to exhibit the results in a tabular form, as collections have not been made with minuteness at a sufficient number of localities to give any definite results, but I can merely state my own experience, that but few species occurred at more than one place, and call attention to the fact that, in every collection made at a fresh locality, a large proportion of new species is found, while in Oregon, at points equally distant from each other, a greater uniformity is seen.

"The analysis, therefore, conducts to the same results announced by me, in 1851, at the meeting of the American Association for the Advancement of Science; the fourth proposition was, unfortunately, announced in too absolute terms, as the only two genera then known to me, Thalpius and Axinopalpus, were not considered as of sufficient importance to modify the result. Thalpius, indeed, is to closely allied to Diaphorus, that we may well expect some of the species of the latter genus to belong to it, while Axinopalpus is by many entomologists not separated from Dromius. The other four American genera common to California and Atlantic America, not found in the tropics—Dichelonycha, Anelastes, Perothops, and Melanactes—upon which I am now obliged to modify the assertion, were subsequently obtained.

"The four propositions mentioned by me in the essay mentioned are:

1. California constitutes a peculiar zoological district, with sufficeient relation to the other districts of America to prove that it belongs to the same continental system.

2. This zoological district is divided into several sharply-defined sub-districts, having a very close resemblance to each other.

As the same mode of distribution obtains in the groups of islands adjacent to the western coast of America, we are led to believe—

3. That the local distribution of a small number of species is the characteristic of the eastern Pacific region, as the extensive distribution of a large number is the prevailing feature of the Atlantic basin.

4. The genera occurring in, but not peculiar to, this district belong to two classes: either (with the exception of Ergates) they occur on the Atlantic Slope of both continents, or, if peculiar to America, they are (with the few exceptions above noted) also found within the tropics." pp. 2-4.

This paper is accompanied by four tables as follows:

I. Genera Common to the Eastern and Western Continents.
II. Genera Peculiar to America.
III. Species Common to the Atlantic and Pacific Slopes of the Continent.
IV. Species Found in Russian America and in the Eastern Continent, not Introduced and not Found in Atlantic America.

1862. p. 336. "Some of the more conspicuous and peculiar species are described below: enough has been stated to show that the affinities of the fauna [of Lower California] are with that of the region extending from the Colorado Desert across to the Rio Grande valley, thereby confirming the results obtained by Prof. Baird and Mr. Cope from the study of the vertebrata collected by Mr. Xantus.

"The limited number of species of these two classes precludes the possibility of the occurrence of many new forms in the region here treated of; but in the number of peculiar species of the much more extensive class of insects seen in Mr. Xantus' collections, we recognize that lower California constitutes one or more provinces of the Interior district, as defined by me in the introduction to my synopsis of the Coleoptera of Kansas and New Mexico.

"The preponderance of Tenebrionidae, both in genera and species seen in the fauna of Upper California and Arizona, has here been partially destroyed. The genera which survive are, however, such as are already known from the last mentioned region. None of those peculiar to maritime California have as yet occurred." p. 336.

1878. pp. 447-448. "The elevated interior region of North America presents peculiarly favorable opportunities for the study of some of the most interesting questions connected with geographical distribution of animals and plants.

"If the materials at our hands be, as indeed they yet are, a very scanty representation of the organic forms now living in that part of the continent, they are, at least, sufficient to indicate the direction in which investigations should be pushed, in order to arrive at definite and final results.

"The peculiarly favorable circumstances to which I chiefly refer at present are dependent on the following points in the development of the region:—

1st. The gradual enlargement of the land-surface at the expense of the circumambient seas during the latest Mesozoic periods.

2d. The gradual elevation of the middle of the continental mass during post-Cretaceous times, so as to greatly modify the climate in respect to both moisture and temperature. These changes have been so gradual, that we may say with certainty (excluding the local eruptive phenomena, which were more numerous, but not remarkably different from those of the present age) there has been no great or paroxysmal disturbance destructive of the land-surface in the elevated plains east of the Rocky Mountains since the deposition of our early Cretaceous strata (Dakota Group).

3rd. While, during the Glacial epoch, the valleys of the mountains were filled with glaciers of moderate size, and the line of permanent ice streams and fields brought to a much lower level, there was an absence of the extensive ice sheets and flooded areas, which in Eastern America destroyed entirely the terrestrial organized beings of the former period.

"It must be inferred from the first and second of these premises that the new land exposed by this gradual development of the continent received its colonies of animals and plants from the conterminous older land-surfaces in various directions, and that the subsequent elevation of the continental mass, by which the moisture was diminished, caused a later invasion of the territory by those genera and species which are characteristic of arid regions.

"We may also conclude, from the third premise that the glacial displacement of species in the Rocky Mountains has been much less than in Eastern America, and that a very small area would be left bare of life on the return to a normal temperature; consequently, the previous occupants of the higher mountains would again return to their former domain, increased by refugees from the circumpolar continent of temperate climate, driven southward by the increasing cold.

"Such being the case, it ought to be possible, with well-prepared lists of the insects of the plains and mountain regions, by comparison with lists of the local fauna of other zoological districts of the continent, to ascertain, with reasonable probability, the invasions from different directions by which, in the first place, the newly emerged land was colonized; and, in the second place,

the modifications, either in distribution or in structure, which have subsequently occurred.

"I have on an other occasion[1] expressed my belief that the study of the distribution of existing insects could give much information concerning former topographical and geographical changes in the surface of the earth. I then gave several examples to show how the distribution of species peculiar in their habits and structure confirmed what was already known by geological investigation of the gradual evolution of the middle part of the continent. I will now advance the additional thesis, that we may obtain somewhat definite information of the sequence, extent, and effects of geological changes in the more recent periods by a careful study of the insect fauna in its totality."

1878a, pp. 470-471. Includes lists of Florida Coleoptera:

1. Florida species also found in the Antilles.
2. Common to Florida and Mexico and partly found in Texas.
3. Common to Texas, Arizona, and southern California.
4. Anomalous common to Florida and South America.
5. Distribution of anomalous species.

Murray, A. 1870. pp. 7, 8, 11-12, 32-33, 36-37, 38, "The position I am about to maintain then is, that, subject to modifications to be afterwards mentioned, all the Coleoptera in the world are referable to one or other of three great stirpes. These three no doubt originally sprung from one stirps, and acquired their distinguishing features by long-continued isolation from each other, combined with changes in their conditions of life. But now we have three, and only three, great strains, sometimes intermingling with each other, sometimes underlying or overlying each other, and sometimes developed into new forms, but always distinguishable and traceable to one or other of the three sources.

"These are—1, the Indo-African stirps; 2, the Brazilian stirps; and 3, what, for want of a better name, I shall call the microtypal stirps, in allusion to the general run of the species composing it being of a smaller size, or, more strictly speaking, not containing such large or conspicuous insects as the others. It is not altogether a satisfactory name, because the stirps does contain some large species, and it is not peculiar to it to abound in small ones. But, taken as a whole, its ingredients are smaller and more modest in appearance than those of the others. The fauna and flora of our own land may be taken as its type and standard. pp. 7-8.

"The Indo-African stirps, as its name implies, inhabits Africa south of the Sahara, and India and China south of the Himalayas, also the Malayan district, the Indian archipelago, and the New Guinea group. This range is less modified by the general introduction of foreign elements than that of the next stirps.

"The Brazilian stirps inhabits South Central America east of the Andes, and north of the River Platte, and furnishes, moreover, a large share in the constitution of North America, but has also received in return a very perceptible tinge from the microtypal stirps.

In the microtypal stirps I include the fauna of Europe, Asia north of the Himalayas, Eastern North America, so far as not modified by the Brazilian element, and, what has less of this strain, the whole of North-west America, California, part of the Mexican fauna, Peru, Chili, the Argentine Republic south of Tucuman, Patagonia, Tierra del Fuego, Polynesia, New Zealand, and Australia. p. 8.

"Let us now turn to the three great stirps, and pass each of them in review, trace their course, and determine their limits. I shall begin with the microtypal stirps (with which we are most familiar). It is the most extensive of the whole, being distributed over the whole world with the exception of the Indian, African, and Brazilian regions; and even they, from various exceptional causes, have a greater or less tinge of it in their faunas. It contains some minor faunas, and these, again, a number of subfaunas. The Europeo-Asiatic region is one of these minor faunas, and of it the Atlantic islands, the Mediterranean, and the Monoglian are subfaunas. Taken as one fauna, the Europeo-Asiatic extends from the Azores east to Japan, the whole of that vast space being inhabited entirely by the same type and, for the most part, by the same species, a few only dropping off here and there, and being replaced by others of the same general character. p. 11.

1. Trans. Am. Assoc. Adv. Science, 1875, Detroit, President's address. [*cf.* Le Conte, '76.]

"The Europeo-Asiatic Beetle-fauna[1] does not stop even at Japan; it passes over into North America by Behring's Straits, or rather, I should say, it is found in North America on the other side of Behring's Straits. In Russian America we have a fresh crop of Europeo-Asiatic form, genera and species; and here another noteworthy circumstance presents itself. It is generally taken for granted that there is a uniform homogeneous arctic fauna which extends all around the arctic circle. It is so, and it is not so. It is so on the large scale, but not so on the small. The arctic fauna is subject to the laws of spreading by continuity and stoppage by barriers just the same as any other fauna. I have elsewhere endeavored to show that the mammalian fauna of Greenland is Europeo-arctic as distinguished from Americano-arctic. I maintain that the homogeneity of a fauna depends on other causes than uniformity of condition of life within its limits. I cannot doubt that if there had been an isolated communication between the Indo-African districts and the North-Pole, we should there have had a fauna related to and developed out of that fauna, and wholly distinct from the other faunas of the arctic regions. It is continuity of soil or freedom of intercommunication which has produced the present uniformity of fauna in the arctic regions; but were minor interruptions exist, or old barriers or conditions equivalent to a barrier formerly existed, there are also subdivisions in the character of the fauna, and in the position of these minor divisions we see the operation of these laws and are able to trace the existence and former position of the barriers. Thus we find two minor subfaunas in Arctic America, an eastern and a western one. Two causes may have produced these. One of these may have been the sea which, it can scarcely be doubted, formerly existed between the Gulf of Mexico and the Polar Sea, in the line of the Missouri and Mackenzie rivers; another may have been that the ground now occupied by one of these subfaunas was under water at a later period than the other, so that it was peopled at a different date from it. Probably both contributed to produce the present arrangement of the subfaunas to the east and west of the Mackenzie River. That there was a barrier there, and that that side was still supplied with the same general type (though with minor deviations), is to be explained by their having received their species from the same general stock, but coming to it from different directions, the one from the east, the other from the west. That the minor differences to which I allude are, in the case of North America, to be referred this cause, and not to mere gradual increase of variation arising from increase of distance, seems to be a legitimate inference from the fact that while the whole of the north of North America, without exception, belongs to the Europeo-Asiatic type, there are a number of European genera which occur in North-east America, and not in the North-west, and *a few which occur in the North-west, and not in North-east America.* pp. 32-33.

"Returning to the Asiatic terminus of the microtypal stirps, let us now endeavor to trace its further course. The genus *Blaps*, which is a characteristic feature in the Coleopterous fauna of Central Asia, will furnish us with the means. It may be taken as a representative case applicable to other species also, although it is the most striking instance which occurs to me. Upwards of 100 different species of *Blaps*, out of a total of about 150, have been described as inhabiting the country between Southern Russia, Mongolia, and Mantchouria. Now if we cross to California in continuation of the same line we have not *Blaps*, but we have *Blaps's* brother and he has been a twin. We have *Eleodes*, its perfect counterpart and representative; and it is to be observed that while the facies of the species actually inhabiting California is entirely that of *Blaps*, a number of species which are found in Kansas and on the eastern flanks of the Rocky Mountains have a somewhat different facies; and I should add that the supposition that these are stragglers from the Californian shores is strengthened by the fact that the genus does not occur to the east of the Missouri; other Heteromerous forms, reminding us of Mediterranean and Asiatic species, occur in California, and the whole of the north-west of America has a greater preponderance of the microtypal stirps than perhaps occurs east of the Rocky Mountains. pp. 36-37.

"Next step to the south of California comes Mexico. It also is largely supplied with *Eleodes;* and although some of the showiest and finest non-microtypal Col-

"[1] I was unable in my 'Geographical Distribution of Mammals' to adopt Dr. Sclater's terminology of Palaearctic, Neoarctic, &c., because we did not agree in the extent and limits of our regions; and now, of course, in this paper I can still less do so, 'as a principal effect of my hypothesis, if it be found, must be to still further break down their limits and destroy their solidity."

eoptera in the whole world come from Mexico, they have no bearing on this part of my inquiry; for they come from parts of Mexico which are in direct communication with another stirps, the rich Coleopterous fauna of Brazil and Venezuela; and the vast multitude of small European-looking species which occur on the high lands and western side is quite sufficient for my purpose. The collections made by Truqui in Mexico show this thoroughly microtypal character in a very marked way, Staphylinidous genera, such as *Falagria*, *Homalota*, &c., abounding. Mexico, being a sort of halfway house between Europe and Australia, might be expected to contain species both from the north and the south which have got thus far. *Eleodes* is an instance of this from the north, *Philonthus* another; both reach as far as Chili, but not into Australia. *Zopherus*, on the other hand, is an instance of a species which occurs in Australia, and runs up into Mexico, where it is in strength, and goes even a little further. Mexico may, indeed, have been its starting-point, but the connexions and relations of it and the allied genus *Nosodendron* decidedly indicate a separation between the eastern and western type of both; and the western type extends into Australia and New Caledonia." p. 38.

Schwarz, E. A. 1888. pp. 166-167, 168-170, 171-172. "After a study of this peculiar fauna of Key West which I also found on many other localities farther north and which constitutes the semitropical fauna of Florida, I have come to the conclusion that it is entirely of West Indian origin, and that the region I shall hereafter circumscribe as Semitropical Florida does not contain any endemic forms. In other words, the distinctive fauna of Southern Florida is a permanent colony of West Indian forms, much more numerous in species than it has hitherto been supposed; the number in Coleoptera alone amounting, according to a very low estimate, based upon my collection, to at least 300 species not yet in our catalogues. pp. 166-167.

"Before entering on a discussion of the character and extent of this West Indian colony in Florida it seems worth while and instructive to give a glance at the south-western extremity of North America where our fauna comes also in contact with a semitropical fauna. The great faunal regions known as Nearctic and Neotropical are connected or divided by the Central American fauna which from the nature of the conditions participates in the characters of both regions, but is more nearly allied to the latter than to the former. It is again divided into the fauna of the Central American continent and the Insular fauna of Central America, more commonly called the West Indian fauna; these two faunal regions being related to each other in the same degree as is the fauna of our Atlantic slope to that of the Pacific slope. At the zone of contact between the North American fauna and that of Mexico the conditions are as follows: The ocean current along the Pacific coast of North America runs from north to south, thus facilitating the spread of more northern species southward. It loses its force and disappears before reaching southern California and thus the North American fauna along the coast does not come into contact with that of the Mexican coast. On the mainland we find between California and the largest portion of Arizona on the one side and Mexico on the other, a broad tract of the most barren and sterile* country which proves to be a most effectual barrier between the two faunal regions. Farther east, and more especially along the Rio Grande, a complete intermingling of the two faunas takes place in such a way that species of all families participate in this intermingling. It is thus impossible to decide whether a collection of insects comes from Texas or the State of Tamaulipas, or whether it comes from southern New Mexico, from south-eastern Arizona, or from Sonora. The Morrison collection, for instance, has been distributed among North American entomologists as coming from south eastern Arizona and is worked up in the 'Biologia Centrali-Americana' as coming from Sonora, Mex. pp. 167-168.

"In looking for the original home of this colony of West Indian insects and plants we have been hitherto too much accustomed to consider the island of Cuba as the only place from which this immigration has taken place. In the task of determining my South Floridian Coleoptera it was found over and over again that these immigrants may have been described not only from Cuba, but from any other of the West Indian islands, or from the Central American continent south of Yucatan, or even from Columbia and Venezuela—in other words from all parts of Central America which come under the influence of the Gulf stream. As can be seen from any physical atlas, the warm equatorial current enters the

*See Dr. G. H. Horn's "Notes on the 'Biologia Centrali-Americana,'" Trans. Amer. Ent. Soc., Vol. XIII, Month. Proc., p. VII.

Caribbean Sea through the Windward Islands and attaining by this contraction a considerable velocity forms the Gulf Stream which flows between the southernmost chain of the West Indies and the Leeward Islands and strikes the Central American continent, flowing northward along the coast. Deflected by the projecting peninsula of Yucatan, the stream turns eastward and reaches the coast of Cuba and the southernmost part of Florida. Thus the West Indian colony of insects in Florida may come from any part of this vast area swept by the Gulf stream, although the largest proportion comes of course from Cuba since this island is the nearest to Florida. This immigration by the aid of the Gulf stream explains the following interesting phenomenon in geographical distribution. We have seen that insects from the coast of Central America south of Yucatan may occur in Southern Florida; but the same species often had the power of extending their geographical distribution northward on the Central American mainland through Mexico, thus reaching the south-eastern limits of the United States. Certain species may occur, therefore, in the United States, in Western Texas or South-eastern New Mexico and in Southern Florida, being however, absent in the intervening Southern States, viz: Eastern Texas, Louisiana, Alabama, Georgia, and Northern and Central Florida. This curious distribution has never been pointed out so far as I am aware but can be exemplified by numerous species, not only among the Coleoptera but also other Orders of insects.

"The distance between Cuba and Florida is not very great, the current of the Gulf stream is very swift, and logs and other debris swept out to sea from the rivers of Cuba may reach the coast of Florida within three or four days; from Yucatan in about double that time. It is evident that within that short time all such insects may safely be carried from the West Indies to Florida which, in the imago or preparatory stages, live under bark, or within the wood of trees, or within seeds and similar sheltered conditions, or whose eggs are firmly attached to trees and covered with viscous liquid. But it is evident that this sea voyage is too long for all such insects as do not live in such sheltered positions. As a consequence, all adephagous Coleoptera, further all those living under old leaves, in the ground, in very rotten wood and similar places, and finally most of the *Chrysomelidae* which lay their eggs either onto the leaves or in the ground are not brought over from the West Indies. There are, therefore, no West Indian *Carabidae, Lampyrdae, Staphylinidae* and other rhypophagous Clavicorn families and very few West Indian *Scarabaeidae* and *Chrysomelidae* to be found in Southern Florida.* This is a most characteristic feature of the semitropical Coleopterous fauna of Florida, strikingly contrasting with the state of affairs in the southwestern extremity of North America. I have stated before that along the Texan and New Mexican frontier there is a perfect intermingling of the North and Central American faunas so that it is impossible to decide whether a miscellaneous collection of Coleoptera comes from Western Texas or the adjacent parts of Mexico. A miscellaneous collection, consisting only of about 100 species but made promiscuously in semitropical Florida can at a glance be distinguished from a similar collection made in Cuba or any other part of the West Indies. Further, the peculiar composition of this fauna at once precludes the assumption that any agencies other than the current of the Gulf stream could have been active in assisting the immigration from the West Indies. pp. 168-170.

"Most of the more southern Keys are covered with semitropical forest, i. e. forest covered with composed of West Indian trees, while, as I stated before, the true Floridian fauna and flora are almost entirely absent. These islands are, therefore, by no means favorable to a study of the relation of semitropical to the true Floridian fauna. However, a stay of a few weeks on the shores of Biscayne Bay fully sufficed to settle this question. Here, as well as on the mainland farther south and the northernmost Keys (Key Largo and Elliott's Key) the Floridian flora largely infringes upon the semitropical forest and reduces the same to smaller or larger island-like patches lying close to the shore or occupying similarly isolated patches on the shore of the Everglades and the few islands in the Everglades. The bulk of the mainland is covered by pine woods† with an undergrowth com-

"* The absence of fresh water in the coral region of the keys and the mainland south of Miami River necessitates the absence of *Dytiscidae* and most other aquatic or semi aquatic families. Even the Everglades and the rivers draining the same at the northern end of Biscayne Bay seem to be almost destitute of aquatic Coleoptera."

"† While it is true that the pine of Southern Florida, *Pinus Cubensis*, is also of West Indian origin, its distribution in Florida is quite different from the rest of the semitropical flora and its introduction is evidently of very ancient date. Its fauna does not differ from that of the Yellow Pine, (*P. palustris*)."

posed almost entirely of true Floridian plants. There are further vast stretches of what is called 'the prairie,' i. e. land quite recently formed, partly by the accumulation of seaweeds swept ashore by the waves, and partly by the advance of the Mangroves. This prairie is covered with the same herbaceous vegetation which we see in similar places in Central Florida and does not contain a single semitropical plant. Even the hammock is invaded by several Floridian trees: the Live Oaks, several Palmettos, the Hackberry and others make their appearance and, on higher ground we find plenty of *Persea carolinensis*. Now on all these trees in the pine woods and on the prairie, in short wherever there is the Floridian flora we meet the true Floridian insect fauna whereas the semitropical fauna is confined to the semitropical forest.* This fact once recognized, it becomes evident that the northward extent of this fauna is identical with that of the semitropical forest, a fact fully borne out by subsequent experience." pp. 170-171.

"I desire to emphasize here once more as one of the principal characteristics of this flora and fauna, that north of the Everglades they nowhere appear inland but always close to the shore. Even along the inner bank of the Indian River there are—or rather were—but a very few spots covered with semitropical forest, viz: on the mouth of the St. Lucie and Sebastian Rivers, at the southern end of Merritt's Island and perhaps some others; but they are now mostly destroyed by cultivation." p. 172.

1890. pp. 186-187.

"The mountain ranges in America run in the direction from north to south, and the colonies of circumpolar insects upon their summits have thus been able to preserve their connection and specific identity with the arctic forms; whereas in Europe, where the mountain ranges run from east to west, the alpine colonies have generally undergone changes and, by isolation, lost their specific identity with the arctic species. There is, therefore, in the Old World an abundance of distinct alpine forms, none of which are identical with North American species; while we, on our high mountains, have but few, if any, alpine, but more arctic forms. pp. 186-187.

"Among the strictly circumpolar Coleoptera the predaceous families predominate over the phytophagous families; the *Carabidae*, *Dytiscidae*, *Staphylinidae*, *and Coccinellidae* are well represented, the *Chrysomelidae* and *Rhynchophera* are tolerably well, and the *Cerambycidae* and *Elàteridae* are poorly represented. The *Buprestidae* are absent although this family contains numerous boreal species in every region. The phytophagous *Scarabaeidae* do not, or barely extend into the arctic regions; the coprophagous *Scarabaeidae* (*Aphodius*) are well represented there, still none of them (with the exception of *Aphodius rufipes*, which doubtfully belongs here) is on the list of circumpolar Coleoptera." p. 187.

"*Species not Belonging to the Circumpolar Fauna.*—This division comprises endemic species of probably intratropical origin, which have spread, by natural dispersion, into the temperate zone of North America." p. 187.

1890a. pp. 170-171.

"Turning now to the bulk of the species in the list [St. Augustine, Florida] we find that they consist of the usual admixture of more or less widely-distributed species and true Floridian forms, the proportion being but little different from that of the other localities, e. g., Crescent City, Enterprise, Tampa. . . But the St. Augustine list contains another element, viz: species belonging to the faunal region lying directly north of eastern Florida and comprising lower Georgia, the lower Carolinas, and eastern Virginia. This is an ill-defined region with very few, or no, peculiar species, and only characterized by a certain combination of a number of southern species. The existence of this faunal region will become evident to any one who, on a summer day, goes from here [Washington] down to Fortress Monroe, Va. The difference between the Washington fauna and that of Fortress Monroe will then be found quite striking. Of this fauna I noticed about twenty species in the St. Augustine list not previously known from Florida." pp. 170-171.

1901. pp. 1, 2, 3.

"Still, southwestern Texas belongs, at least as far as the insects are concerned, to the lower Sonoran fauna, of which it forms a marked subdivision, but with marked affinities to the austroriparian region.

"*There is, in addition, in Southern Florida a maritime fauna of semitropical character, but the number of species composing the same (about 12 in Coleoptera) is so small that it is hardly worth while considering. Its northern extent is still uncertain but it is safe to say that on the eastern coast it does not reach beyond Mosquito Inlet at New Smyrna."

"Collections made at Laredo, San Diego, Corpus Christi and in the lower Nueces river valley prove that, with few exceptions, no tropical forms occur in that section, and the trip on the stage from Alice to Brownsville shows that the character of the country does not change southward until the black alluvial soil of the delta of the Rio Grande is reached. Here, within the bends of the river, as well as along the various backwaters and old river arms (resocas) which dissect the delta, isolated areas or strips of larger or smaller extent are covered with a dense forest having thick undergrowth of varied shrubbery and a rich vegetation of lower plants, the like of which is not seen at any other place in Southwestern Texas. The forest jungles (in Florida they would be called hammocks) are the home of the semitropical insect fauna of Texas, which, so far as known to me, has, previous to the year 1895, never been investigated by any entomologist, since even many of the most abundant species are either entirely new or not yet recorded from the United States. If, confining myself to Coleoptera found by Prof. Townsend or myself near Brownsville, I mention the genera *Agra*, *Dasydactylus*, *Physorhinus*, *Achryson*, *Gnaphalodes*, *Amphionycha*, *Megascelis*, *Plectrotreta*, *Brachycoryne*, *Listronychus*, *Polypria* (quite a number of others are not yet determined, or undescribed), no one can deny the existence of a semitropical insect fauna along the north bank of the lower Rio Grande. The number of species composing this fauna is very large; in Coleoptera alone I estimate that, after proper exploration, between 300 and 400 species will be added to our lists.

As stated above, these semitropical thickets occur in isolated patches in the lowest parts of the delta; wherever the ground is a little more elevated, the usual mesquite and spiny chaparral, liberally interspersed with Opuntias, make their appearance, and with them the general fauna of southwestern Texas."

Scudder, 1895. pp. 27-28.

"The Post-pliocene deposits have proved the most prolific with thirty-two species, though here only seven families are represented, of which the Carabidae and Staphylinidae, but especially the former, very largely predominate. The greatest interest attaches to the interglacial locality near Scarboro', Ont., which alone has yielded twenty-nine species,* and is the largest assemblage of insects ever found in such a deposit anywhere. These clays have been studied and their fossils collected by Dr. G. J. Hinde,† who sets forth the reasons why he regards them as interglacial, lying as they do upon a morainal till of a special character and overlain by till of a distinct kind. The elytra and other parts of beetles found by him represent five families and fifteen genera; they are largely Carabidae, there being half-a-dozen species each of Platynus and Pterostichus, and species also of Patrobus, Bembidium, Loricera and Elaphrus.

The next family in importance is the Staphylinidae, of which there are five genera, Geodromicus, Arpedium, Bledius, Oxyporus and Lathrobium, each with a single species. Hydrophilidae are represented by Hydrochus and Helophorus, each with one species, and the Chrysomelidae by two species of Donacia. Finally a species of Scolytidae must have made the borings under the bark of a juniper described below.

"Looking at the assemblage of forms as a whole and noting the distribution of the species to which they seem to be most nearly related, they are plainly indigenous to the soil, but would perhaps be thought to have come from a somewhat more northern locality than that in which they were found; not one of them can be referred to existing species, but the nearest allies of not a few of them are to be sought in the Lake Superior and Hudson Bay region, while the larger part are inhabitants of Canada and the northern United States, or the general district in which the deposit occurs. In no single instance have any special affinities been found with any characteristically southern form, though several are most nearly allied to species found there as well as in the north. A few seem to be most nearly related to Pacific forms, such as the Elaphrus and one each of the species of Platynus and Pterostichus. On the whole, the fauna has a boreal aspect, though by no means so decidedly boreal as one would anticipate under the circumstances." pp. 27-28. *Cf.* Scudder '94.

Ulke, H. 1902. p. 3.

"The appearance of northern and southern forms are here controlled [Wash-

"* This statement includes four species (*Hydrochus amictus*, *Helophorus rigescens*, *Pterostichus dormitans*, and *Bembidium fragmentum*), found by Dr. Hinde near Cleveland, Ohio, on the shores of Lake Erie, in clay beds very similar to those found near Scarboro', on the shores of Lake Ontario, but not found at Scarboro' itself. They undoubtedly belong to the same category."

"† Can. Journ. Sc., N. S., xv, 388-413 (1887)."

ington, D. C.] by the change of seasons, so in early spring we may always expect more northern types, while in midsummer the southern ones predominate."

VanDyke, E. J. 1901. pp. 198-199.

"The California faunal region proper includes practically all the lowlands of the State, the fertile valleys of southern California and the extensive valleys of the San Joaquin and Sacramento, the lesser valleys along the coast and the foot hills bordering them. The fauna prevailing throughout these portions are so affiliated with Sonoran forms, particularly toward the south as to warrant the designation of such portions as Sonoran sub-regions, and by the extension of these forms into the foot hills where they have interbred with Boreal types through a series of ages, genera characteristic of both parent regions have been evolved. *Omus, Brennus* (a cychrid subgenus), *Metrius, Promecognathus, Pleocoma*, and *Rosalia* with others while more or less related to adjacent northern forms probably developed from a rich circumpolar fauna under the influence of adaptation to environment. *Omus* occurs rather generally throughout the state, and *Metrius* and *Promecognathus* similarly but less frequently in the moist timber belt of the Coast Range, although an Alpine variety of *Metrius* is found in the Sierras, and *Brennus* is confined to the coast. Many other examples of restricted location could be given. In earlier periods California was more isolated particularly from the Sonoran region and northern influences prevailed. Then such genera as *Omus* and *Plecoma* became first established. Subsequently a few southern forms such as *Coniontis* and its congeners gained access. These constituted the old California fauna, but when the southern isolation ceased, followed by the invasion of Sonoran forms, a new and later fauna was developed. This theory is partially supported by the fact that in the islands off the coast and in certain still isolated areas are faunas which are largely *sui generis*, and typical of the old California fauna above described."

Wickham, H. F. 1902. pp. 221-222.

"The phenomena of distribution in Colorado are of much interest. Within a radius of a few miles we may find assemblages of species representing at least three distinct faunae. The first, that of the great plains surrounding the mountains, is marked by a great development of wingless or imperfectly winged forms, probably largely invaders from the south where we may suppose that the arid deserts first made their appearance and where this characteristic feature is more in evidence among the beetles. Good examples may be found among the Meloidae, Tenebrionidae and epigaeal Rhynchophora. Occasionally these forms leave their natural haunts and extend for long distances up the river valleys. Thus Eleodes may sometimes be met with at altitudes exceeding ten thousand feet. As we enter the timbered country on the higher foot-hills and lower mountain sides, we encounter a fauna which while not unmixed with species that have come up from the plains, shows a strong affinity to the life about our Great Lakes. Higher still —that is to say from about eight thousand to nine thousand feet, according to the exposure, presence or absence of near-by snow-fields and so on—we meet with many species of genera still more boreal in habits. We may mention Nebria with its many species, usually taken along the coldest mountain streams, the flattened Bembidia, and the large Aphodii. Above timber line the peaks sustain a few beetles which seem to be of arctic origin, left, probably, by the retreating ice-sheets of the Glacial period.

"I cannot agree with Prof. Cockerell* who claims that the Glacial epoch would, for the time being result in the almost complete extermination of the insect fauna of Colorado and the adjacent table-lands. He assumes that the arid region 'where not actually glaciated would be a frozen desert,' something which I think is not indicated by such geological evidence as we possess. The glaciation of Colorado was apparently not particularly extensive. Neither does it seem likely that the western ice-sheet went so far south as San Diego; at any rate the indications seem to show that along the highlands of Southern California only the loftier mountains were glaciated at all. Today great glaciers exist in the immediate vicinity of well-wooded districts rich in animal life. The same phenomenon may have occurred during ancient times."

1893. pp. 232-233.

"1. That the fauna of southern Alaska is less closely related to our alpine, northern inland, or north-east coast faunae than is that of the Stikine Canon or of Glenora.

"* Transactions of the American Entomological Society, Vol. XX, p. 319.

2. That the Stikine Canon fauna is more closely allied to that of the North and East than is that of the coast, and about the same as is that of Glenora.

3. That the chief relations of all three are in the direction of Lake Superior: with larger lists this affinity might turn to the Rocky Mountains, especially in the case of Glenora.

Regarding the affinities of the faunae of the Coast, the Stikine Canon and Glenora among themselves we find:

4. That one-sixth of the Coast species extend up to the Canon while only one-thirtieth reach Glenora.

5. That the last-named fauna is much more closely allied to that of the Canon that to that of the Coast; nearly one-fourth of the Glenora species are found also at the Canon while only about one-eleventh extend to the Coast.

6. That the fauna of Glenora is apparently less related to that of the Coast than to that of the interior or the East.

"Reference to the accompanying maps will throw some light on the problems here suggested. Glenora is on the inside of the great Coast Ranges while the Little Canon is regarded by Dr. Dawson as marking the head of the old salt-water inlet that has been silted up. This would account for much in the distribution of the species in question. The climate of the country above the Canon is also much dryer and with greater extremes of heat and cold than on the Coast. Aside from the influence of the barrier of the Coast Mountains interposed between faunae which might tend to intermingle, the change of plants consequent upon difference in climate on opposite sides must also have its effect on the insects dependent on vegetation for food." pp. 232-233.

1905. p. 46.

"My proposed explanation, correlating the briefly outlined geological history with the facts offered as to the distribution of the insects [shore insects of the Great Basin], may be summarized as follows:

1. The shore beetles under consideration are confined to the Great Basin or its immediate borders, and have, in general, no allies in other districts from which they could have been recently developed. This in itself is strong presumptive evidence that they are endemic, not immigrants.

2. Within the Basin, recent conditions are such that the present distribution cannot possibly be a matter of modern origin. The small lakes now remaining in the Basin are separated by great tracts of arid desert, impassable to beetles depending on a moist soil for their development and food supply. The nature of these insects is such that they cannot be carried long distances, as eggs or larvae, on the feet of birds or other animals.

3. Ancient conditions, as shown by the geological history through the Pleistocene, were favorable to the diffusion of shore-loving insects through the Basin, because of the much greater extension of the lakes in those times.

4. The insect most thoroughly studied, *Cicindela echo*, is entirely confined, in its present range, to the neighborhood of lakes, from which their size and the presence of nearby springs, may be presumed to have lasted in some form from a remote period—even through times of severe drought. Other littoral forms follow the same general law, though some of them are less sensitive to local conditions.

"From these facts, I think we can come to but one conclusion—the beetles under consideration are types that have inhabited the Basin during the Pleistocene times when the shores of the great lakes stretched over hundreds of miles of what are now desert sands. As the lakes shrunk during times of drought, the insects followed the retreating beaches. Those which attached themselves to bodies of sufficient size or permanence were able to sustain their specific existence, while such as were dwelling on the edges of pools of a transient nature were exterminated altogether. Thus we have the phenomenon of discontinuous distribution, presented not by one species alone but by an entire assemblage." p. 46. *Cf.* Wickham, 1904.

2. *Comments on the Preceding Generalizations and on the Literature of Geographic Distribution.* The American authors who have given special attention to the study of the geographic distribution of our beetle fauna are few in number, but they are very representative men. First and foremost is Dr. J. L. LeConte, the most remarkable and

"exceptional" of American entomologists. A man who, had he devoted himself to subjects of more general interest than insects or to more general problems would, in all probability, have been generally recognized as one of the greatest of American naturalists. Other students who have devoted much attention to distribution, although none have given as much attention to the general principles of the problem as did Le-Conte, are: Schwarz, Hubbard, Hamilton, Wickham and Cockerell. Then there are several authors of local lists which must furnish the basis for comparisons, but only in a few cases do the authors of these local lists attempt to discuss the *general characteristics* of their fauna or compare them with those of other localities. This is certainly an unfortunate omission, particularly so as, in general, the authors of such lists should be the most competent to discuss the main features of their fauna. Of the various local lists, two are to be particularly commended for the ecological notes which they contain: those by Schwarz in Ulke's Washington list, and those by Hamilton, in the Pittsburg list. It is through the ecological influences upon distribution that we must expect the greatest advances in the future study of distribution. In this connection there should be mentioned the studies by Webster on the routes of dispersion of certain species, particularly those of economic importance. A very useful bibliography of local lists of beetles has been published by Hamilton and Henshaw ('91-'92), and still other recent local lists will be found in the bibliography accompanying this paper, although no attempt at completeness is made.

Limited time has prevented a detailed discussion of the quotations as originally intended, but in their present form they are much more accessible than when scattered.

V. The Present Centers of Dispersal of the Beetle Fauna.

The general characteristics of the Isle Royale beetle fauna can only be appreciated through a comparison with other areas, particularly with those of boreal regions and the remainder of the North American continent. Only the major features can here be outlined. It has been thought desirable to consider the subjects from the standpoint of centers of dispersal, rather than from the current taxonomic standpoint because of the emphasis thus put upon the genetic side of distribution and its ecological relations.

In a former paper, (Biol. Bull., 1902, 9, p. 122) the writer listed certain criteria which may be used to determine biotic centers of dispersal and centers of origin. As is well known, centers of origin and centers of dispersal do not necessarily coincide, although all established centers of origin must be centers of dispersal. Centers of origin are very often difficult or impossible to determine with the present state of knowledge; and many are likely to remain so indefinitely. Then there is the possibility, or even probability, that some forms have originated at more than one place, and independently. This certainly complicates the subject of origins, increases the importance of determining them, and means that this method must be repeated in such cases, but not that such determinations are impossible. Centers of origin, either single or multiple, at once become centers of dispersal, and by means of dispersal new centers become established so that there

may be numerous centers of dispersal in wide ranging forms. It should also be again stated that centers of dispersal while not necessarily centers of origin, are likely to beçome such with age, particularly if favored by diverse environmental conditions.

It is desirable to understand clearly what is meant by criteria. As understood by the writer, they indicate the kinds or convenient classes of evidence to which we may turn for suggestions and proof as to the origin and dispersal of organisms. Their value is largely relative, so that they vary much in value, and in their application to various groups. In some cases a criterion may have great weight, while in another taxonomic or ecologic group it may have no value or so little as to be merely suggestive. *Each case must be tested on its own merits.* The main advantage of criteria is the definite form in which they present the problems and in the definiteness which it gives to such inquiries as to origin. The number of criteria needs to be greatly increased by the formulation of those restricted to groups of peculiar taxonomic or ecologic character. It should be clearly emphasized that it is the convergence of evidence from many criteria which must be the final test in the determination of origins rather than the dependence upon any supposedly absolute criterion.

The development of criteria has been largely along taxonomic lines, because taxonomy has been based largely upon structural characters rather than upon the convergence of all kinds of affinities and evidence. For this reason ecological criteria have been largely overlooked. With their increase in number, certain origins and dispersals may be established which otherwise could not be determined.

It should be understood that the breeding range only is of fundamental value in the use of criteria, in the determination of origins and the centers of dispersal. Of course only natural dispersal is considered when criteria and natural centers are involved. Dispersal as influenced by man has peculiarities of its own which have not yet been carefully formulated. Species introduced by man may thus secure many new centers of dispersal.

Aside from historical and paleontological evidence the following criteria may be listed as those which will probably be of value in the study of beetles. They have also furnished the basis for the determination of centers of dispersal and origin of the North American beetle fauna.

1. Location of great or maximum taxonomic differentiation of a type or types.
2. Location of synthetic, primitive or closely allied taxonomic forms or groups possessing convergent affinities.
3. Location of maximum size of taxonomic forms or groups.
4. Continuity and convergence of lines of dispersal.
5. Direction indicated by seasonal appearance; vernal suggesting boreal or montane origin, and aestival as austral or lowland derivation.
6. Direction indicated by continuity and directness of individual variations or modifications along highways of dispersal.
7. Location where the succession of beetle associations or societies reaches the relative equilibrium of a climax association or formation.

8. Location of dominance and great abundance of individuals.
9. Direction indicated by biogeographical or ecological affinities.
10. Location of least dependence upon a restricted habitat, except humid types in arid regions, and analogous cases.
11. Location (when both a center of origin and dispersal) of maximum ecological differentiation in habits, habitats, food, etc. "Adaptive radiation," in part, of Osborn.

By various combinations many additional criteria may be produced. By sorting into groups most of the above criteria will readily fall into either a taxonomic or ecologic class. But it will readily be seen that no sharp distinction can be drawn between the two groups; and further, no particular advantage is gained by such a classification.

The necessarily condensed character of such formulations makes further expansion and discussion desirable, but certain criteria are so well known and easily understood that their discussion is not necessary as in the case of No's. 1, 2 and 4; the remainder will be briefly considered.

3. Maximum size. This should be expected to apply to the larger taxonomic units as well as to the smaller ones. In certain families, genera, etc., there can be no question but that this criterion has great value, although it might not apply to allied groups. The broader outlines of the relationship must be borne in mind and should not outweigh exceptional cases. This relation of large size and centers of origin seems to be supported in part, by Murray's (70, pp. 7-8) primary strains of beetle descent. Two of the three strains, the Indo-African and the Brazilian centers, contain the largest beetles. But this entire subject needs critical study before its value and limitations can be fully understood.

5. Seasonal distribution. Although familiar with this criterion, it was, by an oversight, omitted from my former list of criteria. The northern affinities of the vernal flora have long been known. My attention to this oversight was called by my friend, Mr. A. B. Wolcott. Recently Ulke ('02, p. 3) formulated this, in part, for beetles. But it should perhaps be extended to include montane forms also, as the vernal fauna of the mountains may be expected to extend their breeding range downward, where they will appear as vernal forms at lower altitudes. At the same time the fauna at lower altitudes might tend to spread up the mountains where they would occur at the height of the summer season. I do not know that this subject has been investigated.

The late fall feeding habits and the lack of ability to resist low temperature on the part of certain species which are extending their range, may be indicative as to their direction of origin. Many plant feeding insects, acclimated to northern localities, tend to cease feeding some time before the fall frosts and are thus better able to resist low temperatures (cf. Bachmetjew, '99, Zeit. wiss. Zool., 46, p. 600) than those which feed late and are well fed. Chittenden ('01, p. 74) has recognized this general tendency, but has not correlated it with Bachmetjew's results.

It is highly probable that there are many other seasonal phenomena which indicate, in a general but more or less definite manner, the direction of origin.

6. Continuity and directness of individual variations. The continuity and directness or definiteness of individual variations along routes of dispersal may give very definite information as to the direction of origin. This is perhaps not of universal application but carries much weight under certain conditions. For example, continuity of variations, as dwarfing or increasing size, have a certain definiteness which clearly points in a limited number of directions, when correlated with highways of dispersal (cf. Horn '72, p. 383). This is particularly so when a route is of a restricted character, as a drainage line, or a valley. If these variations were entirely promiscuous along lines of dispersal, there could be no idea of direction; but by taking into consideration the entire range, as one is perfectly justified in doing, continuity and directness clearly point in a given direction. It is mainly when the animals along a route are uniform or promiscuous that direction cannot be determined by the character of the variation. This criterion, as restated, like most other criteria should not be used independently. Compare Tower '06, pp. 12-13.

7. Geographical centers and climax associations. To apply this ecological criterion it is necessary to understand the principles which underlie the succession of beetle associations or societies. By a beetle association is meant that combination of beetles which occur associated in the same breeding habitat. As the environmental conditions upon which beetles depend change, the beetles also change and thus a succession is produced. The same general principle holds for a beetle association. Thus as the conditions change the association also changes and a *succession of beetle associations* is produced. When, however, a relatively complete adjustment or equilibrium is acquired, and changes become slight, a self perpetuating or climax association or formation has become established. Areas occupied by formations, through their abundance and dominance, become centers of dispersal, although they are probably more productive or originative, at an intermediate stage, before the dominance of the climax association is fully established.

Members, therefore, of such climax associations may be expected to point in the direction of such centers as include their associated species. If such a relation is valid, the various characteristics of climax associations will aid in the determination or location of centers of origin and dispersal. Such criteria may have more value in determining centers of dispersal than those of origin. This criterion will probably apply to secondary societies, but with attenuated force.

8. Dominance. This is a fundamental criterion in the determination of ecological associations. The tendency for certain associated species to obtain exclusive possession of any given area implies the abundance of individuals and their dominance. This idea is prevalent and fundamental in ecologic studies. This is also a relative term, and like all other criteria, has its limitations. Dominance in a desert must in general have a different meaning than in a humid area.

9. Biogeographical or ecological affinities. In its broader application this criterion is applicable to general biotic relations and to large areas. It is one of the oldest criteria used in the determination of faunal and floral affinities. In some respects it is closely related to No. 7. This

criterion can be illustrated by reference to the Ajax Butterfly (*I. ajax*). The sole food plant of the Ajax larva is the Pawpaw, a shrub clearly of tropical origin. The allies of *Ajax* are also tropical; thus the associated biogeographic (plant and animal) affinities clearly point to the tropics. It is this combination of certain ecological relations or associations which show biogeographic affinities. Thus food and other habits and instincts become of special value. Here also belongs a large class of ecological relations, particularly those related to the succession of insect associations. The great dependence of insects, as a class, upon vegetation necessitates a close relation between the succession of plant associations or societies and certain species of beetles. If certain members of a biotic (plant and animals) association or society have certain geographic affinities, others associated with them are likely to have similar affinities (cf. Horn '72, p. 384). This phase is not identical with the idea of faunal or floral affinities, it includes them and the relation of *biotic association*, particularly as members of a climax association or formation, when geographic affinities are to be determined.

This criterion is of very extensive application. It is really a group of criteria and not a single one, because associations include not only organisms in close proximity, but also commensals, symbiots, parasites, etc. Seasonal phenomena might well be included within this class.

10. Least dependence upon a restricted habitat. From the standpoint of animal associations this is a criterion which may be expected to have a rather extensive application. Its most conspicuous application is to that of dispersal. Out-lying colonies tend to have a limited or restricted range. At the same time such colonies are particularly liable to become extinct, as they are usually near the limit of favorable conditions. Often beetles in such a location are dependent upon a single food plant, etc. This is true of the "boreal islands" in swamps within the glaciated portion of the continent. For example, members of the tamarack bog association, toward their southern limit, have very restricted or local range; but to the north, the bog forest conditions, as it were, spread from the bogs proper and become of extensive geographic range, as the water beetles invade the damp mosses (Wickham, '97, p. 126). The outlying tropical "islands" bordering the Rio Grande, as described by Schwarz ('01) and Wickham ('97a), apparently illustrate the same phenomena. These restricted, attenuated, or isolated colonies, dependent upon special conditions, are clearly indicative that they are pioneers or relicts, which point toward the region where their range is spread out and becomes of geographic extent. But it does not follow that every isolated habitat has such a meaning. In general, a study of succession in the region will determine to which class the colony belongs, pioneer or relict.

There is an exception to this criterion in the case of semi-aquatic or aquatic animals in an arid region. In such regions the springs, streams, and water basins are so limited in extent that their isolation is conspicuous; and yet these conditions may be very favorable to the formation, or at least preservation, of new variations and species. Thus an arid region may be particularly favorable, in a sense, to the formation of varieties and species, although individuals may not be numerous. In such cases the amount and kind of differentiation with-

in the area should carry more weight than abundance of individuals. But by the proper correlation of criteria, such cases will not be confusing. This sort of differentiation is well shown among beetles by Wickham, '04, '05.

This criterion evidently does not apply, at least in part, to the fauna now found in glaciated North America. This is made probable through origin elsewhere and a later expansion in the glaciated area as the Ice Age declined.

11. Ecological differentiation. Ecological and taxonomic differentiation need separate recognition, although they are frequently not distinct because of their intimate genetic relations. With great taxonomic diversity, within a group, there is almost certain to be ecologic diversity; but generally much less attention is given to the ecological diversity. Compare No. 1.

The following outline of the centers of beetle dispersion must be considered provisional and suggestive, as it is a subject which has received but little attention from the standpoint here presented. The preceding criteria, of taxonomic and ecologic nature, have been given much emphasis in locating the present centers of dispersal. Throughout this section references are given to significant papers, but this does not imply that the views here presented are approved by the authors to whom reference is made. These references also apply to the quotations already given in detail.

1. *The American Tropical Center.* From Panama northward to the Mexican plateau is the main body of the tropical center. Narrow elongations extend coastwise on each side of the plateau, and on the Gulf Coast to the Rio Grande river. William Wickham '97a; Schwarz '01; Townsend '95, '97; Tower '06. Outlying colonies are found on the Pacific coast of Mexico and at the Southern extremity of Lower California; at the mouth of the Colorado river (Schwarz); and in southern Florida (LeConte '78a; Schwarz '78, '88). The fauna of the West Indian Archipelago probably belongs with this great composite center.

A vast number of beetles are characteristic of this complex area. The Biologia Centrali-Americana devotes thirteen volumes to the description of beetles from part of this area. Within the United States the attenuated tropical element has been most carefully studied and its faunal affinities determined by Schwarz ('88) and Wickham (97a).

This tropical center is composed of several distinct units. This is an ancient center of origin, preservation and of dispersal. The routes of dispersal into the United States have been along both coasts of Mexico and via the West Indies. It was practically uninfluenced by the Ice Age.

2. *The Mexican Plateau and the Southwestern Dry Desert.* This center includes the Mexican Plateau; most of Lower California; the deserts of southwestern United States; the low lands of California; the Great Basin and the Great Plains northward into Canada and east to the forests. LeConte '51, '59, '60, '62; VanDyke '01; Wickham '96, '98, '04, '05; Tower '06; Fall and Cockerell '07.

Characterized by numerous desert species; wingless Tenebrionidae (Horn '71), and Cicindellidae. A given locality is characterized by a

limited number of species which are individually abundant; numerous local faunae. Contains the characteristic desert fauna of North America.

Influenced markedly by glaciation only at the extreme north, and possibly in the Great Basin, but certainly by the great fresh water lakes formerly occupying this basin (Wickham '04, '05). An old (pre-Glacial) center of origin, preservation, and center of dispersal.

3. *The Southeastern Humid Hardwood Forest Area.* This area includes much of eastern United States east of the plains (exclusive of southern Florida), and north to the Canadian conifers. The Coastal Plain (and possibly the Mississippi Embayment area) may form a subcenter through the influence of its conifers (Schwarz '90; Chittenden '00, '01).

Local lists within this center: Summers '74; Schwarz '78; Ulke '02; Dury '02, '06. cf. LeConte '78a.

Characterized by the abundance of forest insects, particularly those infesting hardwoods; species of extensive range; few local fauna; a large number of species found in a given locality, often but few individuals.

An ancient centre of origin, preservation and dispersal. Glaciated on the north, and post-Glacially repopulated, as was also the Coastal Plain and Embayment, with the elevation of the Coastal Plain.

4. *The Transcontinental Conifer Area.* This area includes the remainder of forested North America, and includes all of the higher mountain ranges. Its relation to the Coastal Plain conifer belt has not been determined.

Characterized by conifer feeding beetles, Cerambycids, Scolytids; numerous Carabids and Staphylinids, and thus shows a decided subarctic circumpolar affinity. Few endemic elements and local faunae. Extensive range of species, except in the high mountains. Largely a new land surface through glaciation; largely repopulated at a relatively late date; apparently characterized by dispersal or diffusion of forms rather than for their origin or preservation, except the mountain areas of the United States, which were areas of preservation and origin.

The very different history of its eastern portion, with much more extensive glaciation, is to be contrasted with the moderate western glaciation. The differences in the character of the forests is also marked; the giant western conifers are to be constrasted with the smaller conifers of the Northeast. The Mackenzie Basin and the Plains mark the line of division between these subcenters. This division is so marked that it may yet necessitate a complete severing of the transcontinental conifer belt. (cf. Murray '70, pp. 32-33.)

a. *The Eastern Canadian Conifer Fauna.*

This includes Canada east of the Rocky Mountains, north to the tree limit and the interior of Alaska; northeastern United States; and southward on the Appalachians.

Characterized by forms of extensive subarctic range, very few endemic elements or those peculiarly American; individuals abundant, variety moderate; beetles feeding on conifers, birches, and aspens. LeConte '50, '59, '78b. There is a possibility that this fauna has North

European affinities stronger than Asiatic ones; the reverse from the western conifer center.

Local lists including this fauna: Hubbard and Schwarz '78; Harrington '84; Wickham '97; Hamilton '94, 94a, '95, Klages '01.

b. *The Western Canadian Conifer Fauna.*

This includes the western mountains northward and upward to the tree limit, eastward to the Great Plains and the eastern Conifers. North of the United States this area has been extensively glaciated but within the United States the glaciers were local.

On account of this moderate glaciation in the mountains of the United States, this old land surface has been a center of origin, preservation and dispersal. It contains more endemic elements than the eastern conifer center, and more local faunae. Beetles feeding upon conifers and aspens are fairly characteristic. The Asiatic affinities of the fauna are much more pronounced than those of the eastern conifer center. Part of the apparently European influence may more truly be considered Asiastic—both the Western and European—having been derived from Asia. Elements of this fauna probably survived the Ice Age on the Pacific Coast north of the United States, but the humid interior has been invaded from the south, or is endemic. LeConte '76; Wickham '96; Cockerell '93; Hamilton '94, '94a; Fall and Cockerell '07; Keen '95.

5. *Alpine and Arctic.* This fauna occupies the area north of the tree limit, and above the tree limit on the mountains. This fauna is very imperfectly known and is limited in variety and in the number of individuals. Many species are of circumpolar range in the Arctic regions. Composed of very diverse elements and of diverse origin. The unglaciated arctic areas are probably centers of origin as well as of dispersal, as also slightly or moderately unglaciated alpine areas. The glaciated portions have been repopulated and show incipient endemism but are mainly characterized by the extensive dispersal of species, as is apparently true of unglaciated Asiatic Siberia. Both of these centers (Alpine and arctic) have been much confused with regard to whether they are centers of origin or of dispersal. These types are currently stated as of boreal origin, but this is very improbable for perhaps the majority of the population. They may be of alpine origin on the western mountains with an extensive post-Glacial dispersal favored by climatic conditions, and the low topographic relief of the northern land areas. Schwarz '90; Murray '70, pp. 32-33.

Eastern Alpine, Scudder '74; Bowditch '96.

Western Alpine, Carpenter '75; LeConte '78, '79; Schwarz '90; Cockerell (including Horn) '93; Wickham '03; Fall and Cockerell '07.

VI. The General Characteristics and Affinities of the Isle Royale Fauna.

1. Faunal Characteristics. The accompanying list of beetles collected in 1905 includes 89 species. The only previous list is that by Hubbard and Schwarz ('78) in which they list 123 species. A surprising feature of our 1905 collections is that of our 89 species, 66 are not listed by Hubbard and Schwarz. Such species are indicated by the

letter A. following the scientific name. On the basis of these two lists, 206 species are now recorded from the island. It is not improbable that other species have been recorded in the scattered literature, but no effort has been made to search for them. Undoubtedly only a fair start has been made in the study of the beetle fauna. Careful detailed collecting, covering several years, would probably increase the number about five times, or bring it up to about 1,000 or 1,100 species; that is, judging from other northern localities. Pettit has recorded from Grimsby, Ontario 1,143 species and Harrington ('84) from Ottawa 1,003 species. On the other hand it is not improbable that the present known 206 species give a fair sample of the dominant features of the beetle fauna. Wickham's ('97) Bayfield, Wisconsin list contains 691 species (six weeks collecting by an expert). Such statistics mean but little, beyond showing the reduction in variety toward the north when compared with southern localities. The two best local southern lists—the best in America—are those by Ulke for Washington, D. C., with 2,975 species, and by Dury for the region about Cincinnati with 2,290 species. Two important intermediate locality lists between these northern and southern ones are from the vicinity of Allegheny and Pittsburg by Hamilton, in which 2,153 species are listed or 2,500 as given by Klages; and at Buffalo, where about 1,424 species are listed by Reinecke and Zesch. The variety in beetle life is thus seen to drop off about ½ or more in passing from the latitude of Washington and Cincinnati to that of Lake Superior and the St. Lawrence valley.

2. *Miscellaneous Notes on the Fauna.* In the present list there are included 6 species which in the Hubbard and Schwarz list are indicated as "Species found by Dr. LeConte, mostly catalogued in Agassiz' Lake Superior, p. 203-239, which have not since occurred." These species are as follows: *Carabus seratus, Calthus gregarius, Blechrus nigrinus* (*linearis* Lec), *Harpalus ruficollis, Pachyta liturata, Donacia proxima.* All these and other rare species turned up in our collection.

LeConte and Horn describe the following three new species from Isle Royale specimens in the Hubbard and Schwarz paper: *Habroceras magnus* Lec., p. 598; *Phymatodes maculicollis* Lec., p. 614 (from one specimen); *Orchestes canus* Horn, p. 620. None of these species were found in our collection. LeConte ('78, p. 463) described *Magdalis alutacea* (*armicollis* Say) from Colorado and Isle Royale specimens.

As numbered in the accompanying list of species collected during 1905, the following are not to be found in the Bayfield list by Wickham; No's. 2, 6, 7, 10, 12, 15, 16, 17, 18, 20, 21, 22, 25, 27, 30, 34, 36, 41, 50, 52, 53, 55, 56, 59, 60, 62, 64, 73, 76, 77, 79, 81, 85, 86,—35 species.

VII. LISTS OF ISLE ROYALE BEETLES.

1. LIST OF SPECIES COLLECTED IN 1905.

Cicindelidae.

1. *Cicindela longilabris* Say. A. One specimen of the dark form was taken from the clearing about Neutson's resort (IV, 5) on July 21 (G. 121).

Geographic Range. Newfoundland; Ottawa, Canada; Hudson Bay; Nova Scotia; Quebec; Mt. Washington (summit), N. H.; Michigan; Wisconsin; Nebraska; New Mexico; Colorado (10,000-12,000 ft.); Utah; Idaho; Montana; Alberta; California; Oregon; Alaska.

Carabidae.

2. *Carabus serratus* Say. A. A single specimen was found crawling over and through the tufts of *Cladonia* in the rock opening near camp on Siskowit Bay (V, 3) on August 5 (G. 208).

Geographic Range. Saskatchewan Basin, Canada; Mt. Washington, N. H.; W. Penna.; Michigan; Indiana (A. B. Wolcott); Chicago, Ill. (Wolcott); Kansas; Colorado; New Mexico. Hamilton '94a, p. 354.

3. *Calosoma frigidum* Kby. A. A single specimen was found on July 7 among the drift on the beach (I, 1) near Tonkin Bay (A. 7).

Geographic Range. Drummond's Island, Ottawa, Canada; Mt. Washington (summit) N. H.; New York; Chicago, Illinois (Wolcott); W. Penna.; Michigan; Indiana; Wisconsin; New Mexico; Texas.

4. *Bembidium carinula.* Chaud. A. "Very abundant July 8 on the sandy beach at the head of Conglomerate Bay (I, 1). Running rapidly over the sand and fine gravel just back of the wet strip along the shore." (G. 30), Gleason.

Geographic Range. New Hampshire; Mass.; Adirondack Mts., New York; Port Arthur, Ontario; Saskatchewan Basin, Canada; Georgia; Ohio; Michigan; Indiana (Wolcott); Illinois; Wisconsin; Arkansas; Colo. (8,000 ft.); Oregon; Brit. Columbia. Hayward, '97, p. 46.

5. *Bembidium transversale* Dej. Two specimens were taken about the camp at the Light-house (I, 7) on July 11 (G. 49).

Geographic Range. Canada; Gulf of St. Lawrence; Lake Superior region; Mich.; Wisconsin; Nebraska; Kansas; Colo.; New Mexico; Arizona; Wyoming; Utah; Pacific Coast from So. Calif. to Alaska.

6. *Bembidium grapii* Gyll.=*nitens* Lec. A. "On a low bare rock on the shore near the Lighthouse at Rock Harbor (I, 1). On July 11, early in the morning, with air temperature of 51° F. and surface temperature about the same, no specimens were seen; but as the surface grew warmer, up to 95° F., the beetles became abundant. They probably conceal themselves in crevices in the rock when the temperature is low." (G. 46.) Gleason.

Geographic Range. Greenland; Hudson Bay region, Saskatchewan and Mackenzie Basins; Isle Royale, Michigan; White Mts., N. H.; New York; southward on the mountains of the west to Colorado, New Mexico and

Nevada; Alaska; Siberia; Northern Europe. Hamilton, '94, p. 8; '94a, p. 351.

7. *Bembidium variegatum* Say.=*patruele* Dej. "In debris cast up on the beach at the head of Tonkin Bay (I, 1) with *B. versicolor* and *Platynus*." (G. 21). Gleason.

Geographic Range. Nova Scotia; New England States; New York; New Jersey; Penna.; Maryland; Distr. Columbia; Texas; Ohio; Michigan; Lake Superior region; Wisconsin; Illinois; Iowa; Missouri; Nebraska; Saskatchewan Basin, Manitoba; Colorado; Nevada; Calif. to Brit. Columbia.

8. *Bembidium versicolor* Lec. A. "In debris at the head of Tonkin Bay (I, 1) with *B. variegatum* and *Platynus 4-punctatus* (G. 21)." Gleason.

Geographic Range. General distribution in Canada and United States; from Anticosti, Quebec to Florida; Texas and California and north to Colorado and Manitoba; Pine, Ind. (Wolcott).

9. *Pterostichus coracinus* Newm. A. A specimen of this species was taken in the Lighthouse clearing (I, 7) on July 11 (G. 49) and on July 28 (G. 179).

Geographic Range. Ottawa, Canada; Mt. Washington (summit) N. H.; Vermont; New York; New Jersey; W. Penna.; Maryland; Virginia; Dist. Columbia; Tenn.; Ohio; Mich.; Northern Illinois; Iowa; Wyoming.

10. *Pterostichus femoralis* Kby. A. A specimen of this ground beetle was found under *Cladonia* upon a sloping rock shore (V, 2) just beyond the reach of the waves, on August 16 (A. 130).

Geographic Range. Ottawa, Ontario; Saskatchewan Basin; Mass.; Mich.; W. Penn.; New York; Ohio (Dury); Colo.; New Mexico; No. Ill. and Ind. (Wolcott).

11. *Calathus gregarius* Say. A. A specimen was taken on or in leaf mould in a deeply shaded balsam-spruce forest (I, 3) on July 24 (G. 140), and (V, 4) on August 14 (G. 236).

Geographic Range. Ottawa, Ontario; Quebec; Saskatchewan Basin; Vermont; New York; New Jersey to Florida and Texas; W. Penna.; Ohio; Mich.; No. Illinois (Wolcott); Wisconsin; Iowa; Kansas; Nebraska; New Mexico.

12. *Calathus advena* Lec. A. "One was found crawling through soft decayed wood in the balsam-spruce forest (I, 3) on July 24 (G. 142)." Gleason.

Geographic Range. Maine; Vermont; Mt. Washington, N. H.; Michigan; Colorado; New Mexico; So. Alaska. Hamilton, '94, p. 11.

13. *Platynus 4-punctatus* DeG. A. A single specimen of this species was found about camp at the Lighthouse (I, 7) on July 11 (G. 49), also in debris cast up on the beach at the head of Tonkin Bay (I, 1) where it was found alive (G. 21).

Geographic Range. Ottawa, Ontario; Canada; Hudson Bay and Lake Superior regions; Mt. Washington, N. H.; New York; W. Penna.; Mich.; Wisconsin; Idaho; Colorado; New Mexico; Montana; Alaska; Kamchatka; Siberia; Northern and Alpine Europe. Hamilton, '94, p. 11.

14. *Blechrus nigrinus* Mann.=*linearis* Lec. "In the debris under mats of bearberry on the rock ridge north of the Lighthouse at Rock Harbor (I, 3), (G. 64)." Gleason.

Geographic Range. Saskatchewan Basin, Canada; New York; New

Jersey; Mich.; Iowa; Wisconsin; Missouri; Dakota; Wyoming; Colorado; New Mexico; Calif.; Brit. Columbia; possibly Siberia and No. Europe. Hamilton, '94a, p. 355.

15. *Harpalus megacephalus* Lec. "In rock crevices and under debris from bearberry on the jack pine ridge (1, 2) on July 13 (G. 72)." Gleason.

Geographic Range. Lake Superior; Isle Royale, Michigan.

Haliplidae.

16. *Haliplus ruficollis* DeG. A. "At the bottom of small pools in the partially drained sphagnum bog near Conglomerate Bay (I, 6) on July 18 (G. 116), and at the bottom of a small stream flowing from a tamarack swamp near Siskowit Bay (V, 5) on August 12 (G. 230). In each case the water was shallow and the bottom composed of sphagnum covered with dead leaves." Gleason.

Geographic Range. Canada; Hudson Bay region; Mt. Washington; New Hampshire; Vermont; New York; New Jersey; Mich.; W. Penna.; Ohio; Ill. (Wolcott); Iowa; Colo.; New Mexico; Texas; Wyoming; Kansas; Western Siberia; Europe; Turkestan. Hamilton, '94a, p. 355.

Dytiscidae.

17. *Hydroporus tristis* Payk. A. "In the bottom of small streams draining a tamarack swamp (V, 5), (G. 237)." Gleason.

Geographic Range. Ottawa, Ontario; Vermont; Mass.; Mich.; Lake Superior region; Hudson Bay; Colorado; British Columbia; Alaska; Arctic Siberia; Northern Europe to Finland. Hamilton, '94, pp. 13, '94a, 357. Sharp, '82, p. 472.

18. *Hydroporus modestus* Aube. A. Taken at Benson Brook clearing (II, 1) on July 29 (A. 81).

Geographic Range. Ottawa, Ontario; Mt. Washington, N. H.; Mass.; W. Penna.; New Jersey; Dist. Columbia; "Carolina"; Wis.; Mich.; Ohio (Dury). Sharp, '82, p. 480.

19. *Ilybius pleuriticus* Lec. A. "In the water near the shore at camp on Siskowit Bay (V, 1) on August 7 (G. 213)." Gleason.

Geographic Range. Penna.; New York; Isle Royale, Mich.; Bayfield, Wis.; Iowa; Colorado.

20. *Agabus stridulator* Sharp. A. Taken in a clearing (II, 1) on July 29 (A. 81).

Geographic Range. Isle Royale, Mich.; Hudson Bay; Canada. Sharp, '82, p. 509.

21. *Agabus congener* Payk. A. "In the bottom of streamlets draining a tamarack swamp (V, 5), (G. 237)." Gleason.

Geographic Range. Greenland; Labrador; Hudson Bay; White Mountains N. H.; Mass.; Penna.; Mich.; Missouri; Arctic and Western Siberia; Central and Northern Europe. Hamilton, '94a, p. 358. Sharp, '82, p. 513.

22. *Scutopterus hornii* Cr. A. "In small pools in the tamarack and arbor vitae swamp (1, 4) on July 28. These pools were under fallen logs and at the bases of trees; seldom more than 1.5 dm. in depth and with a bottom of sphagnum and vegetable debris (G. 181, 182)." Gleason.

Geographic Range. Canada; Isle Royale, Michigan.

23. *Rhantus binotatus* Harr. A. Two were found in rock pools on the beach at the entrance to Tonkin Bay (I, 1) on July 13 (G. 73, 74) and at Scovill Point (IV, 1) on July 19 (G. 130). The beetles usually remained on the bottom except when they came to the surface for air.

Geographic Range. Labrador; Ottawa, Canada; Hudson Bay region; Brit. Columbia; Mt. Washington, N. H.; New York; New Jersey; Mich.; Wisconsin; Kansas; Nebraska; Colorado; New Mexico; So. Arizona; Utah; Nevada; Calif.; Lower Calif.; Mexico; Guatemala. Sharp, '82, p. 614.

Gyrinidae.

24. *Gyrinus minutus* Fab. A. "In sheltered coves of Siskowit Lake (V, 6) on August 9, where the water was quiet. Most numerous near the shore under the overhanging alders where they congregated in large flocks (G. 219)." Gleason.

Geographic Range. Labrador; Canada; Hudson Bay region; Saskatchewan basin (Evans '03); Vermont; W. Penna.; Michigan; Wisconsin; Washington; Oregon; Siberia; Central and Northern Europe. Hamilton, '94a, p. 360.

25. *Gyrinus picipes* Aube. A. In large numbers near the shore of Siskowit lake (V, 6) with the preceding species (G. 219).

Geographic Range. Labrador to Brit. Columbia; Vermont; Michigan; Idaho; Oregon; So. Alaska. Hamilton '94, p. 14.

Staphylinidae.

26. *Gyrophaena* species. "Several specimens (G. 229) were taken from a shelf fungus, *Pleurotus ostreatus*, on August 11 (V, 4)." Gleason.

27. *Quedius fulgidus* Fab. A. Two were taken from leaf mould or under decayed bark in the maple forest (III, '04) on August 21 (A. 142).

Geographic Range. Greenland to Alaska; south to No. Georgia and La. and Central Calif.; Peru; Mich.; West Siberia; Europe; Asia Minor; No. India; Java; Tasmania; Australia; New Zealand. Hamilton, '94, p. 18, '94a, p. 366.

28. *Philonthus politus* Linn.=*aeneus* Rossi. A. Hamilton, '94a, p. 19. One specimen was taken about camp at the Lighthouse (I, 7) on July 7 (G. 26).

Geographic Range. Isle Royale, Mich.; Nova Scotia; Hudson Bay region; British Columbia; New York; Mass.; Penn.; New Jersey; La.; Ohio; Illinois (Wolcott); Wisconsin; Iowa; Kansas; Colorado; New Mexico; Queen Charlotte Island; Alaska; Siberia; Amur region; Europe.

29. *Lathobium simplex* Lec. A. One specimen (A. 24) was taken July 17 on a jack pine ridge (I, 5).

Geographic Range. Canada; Mass.; New York; Michigan; Wisconsin, Am. Ent. Soc., '80, p. 176.

30. *Tachinus memnonius* Grav. A. One beetle was found under the bark in the hardwoods along the Desor trail (III, '04) on August 24 (A. 149).

Geographic Range. Dist. of Columbia; W. Penna.; Ohio (Dury); Wisconsin; Michigan; Ill. (Wolcott).

31. *Boletobius cincticollis* Say. "In fresh plants of the bracket mushroom *Pleurotus* sp. growing in the balsam-spruce forest (V, 4) on August 11." Gleason. One specimen (G. 229).

Geographic Range. Canada; New York; W. Penna.; New Jersey; Dist. of Columbia; Ohio; Wisconsin; Iowa; Mich. to Brit. Columbia; Calif. and Arizona; cf. Hamilton, '94, p. 21, Alaska.

Coccinellidae.

32. *Hippodamia 13-punctata* L. A. Taken about camp at Rock Harbor (I, 7) on July 14 (G. 98).

Geographic Range. "All America north of Mexico;" West Indies; Alaska; throughout Europe and Central Asia; Siberia. Hamilton, '94a, p. 378.

33. *Anatis 15-punctata* Oliv.=*ocellata* L. A. Found among drift cast up on the beach at the head of Tonkin Bay (I, 1) on July 6 (G. 21).

Geographic Range. Ottawa, Saskatchewan basin, Canada; Nova Scotia; New York; New Jersey; West Indies; W. Penna.; Ohio; Illinois; Mich.; Wisconsin; Iowa; Siberia; Europe. Hamilton, '94a, p. 379.

Erotylidae.

34. *Tritoma macra* Lec. A. "One specimen (G. 229) found August 11 in a shelf fungus *Pleurotus ostreatus* (V, 4)." Gleason.

Geographic Range. Maine; Michigan; Illinois; W. Penn.

35. *Tritoma thoracica* Say. A. From fresh specimens of *Pleurotus* growing in the balsam-spruce forest (V, 4) on August 11 (G. 229).

Geographic Range. Hudson Bay region; Saskatchewan basin; Ottawa, Canada; Vermont; New York; New Jersey; Va.; Georgia; Florida; Texas; W. Penna.; Ohio; Illinois; Mich.; Wis.; Iowa; Colo.; New Mexico; Washington.

Dascyllidae.

36. *Macropogon rufipes* Horn. A. One specimen was found upon the beach of Lake Superior (I, 1) on July 12 (G. 60).

Geographic Range. Illinois; Isle Royale, Mich.; White Mts., N. H.; Horn, Amer. Ent. Soc., '80, p. 80.

Elateridae.

37. *Adelocera brevicornis* Lec. A. One taken about camp at the Lighthouse (I, 7) on July 18 (G. 117).

Geographic Range. Ottawa, Canada; Mich.; Wisconsin; Lake Superior.

38. *Elater hepaticus* Mels. A. Two taken about the camps both at the Lighthouse (I, 7) on July 13 (G. 86), and at Siskowit Bay (V, 3) on Aug. 7 (G. 212).

Geographic Range. Canada; Vermont; W. Penna.; New Jersey; Ohio; "Western States;" Wisconsin; Michigan.

39. *Elater apicatus* Say. A. One taken at the camp on Siskowit Bay (V, 3) on August 3 (G. 195).

Geographic Range. Saskatchewan basin; Ottawa, Canada; New Hampshire; Vermont; New York; Mich.; Wis.; Duluth, Minn. (Wolcott); Colo.; Arizona; New Mexico; Idaho; Wash.; Oregon; Calif.; "Northern U. S. generally."

40. *Agriotes limosus* Lec. Taken on flowers of the Cow Parsnip (*Heracleum lanatum*) in the clearing at the Light-house (I, 7) on July 17 (G. 105) and on July 23 (G. 136). Five specimens.

Geographic Range. Newfoundland; Mt. Washington (summit), N. H.; Ottawa, Canada; Lake Superior; Saskatchewan basin; Michigan; Wisconsin.

41. *Melanotus paradoxus* Melsh. A., One taken about the camp at the Lighthouse (I, 7) on July 11 (G. 49), and near Lake Desor (VII, '04) on August 21 (A. 139).

Geographic Range. Isle Royale, Mich.; Colorado; New Mexico (Snow).

42. *Corymbites medianus* Germ. One taken on the beach south of Tonkin Bay (I, 1) on July 10 (G. 41), "crawling over the sand in a shaded place near a rock cliff." Gleason.

Geographic Range. Ottawa, Canada; Mt. Washington (summit), N. H.; New York; W. Penn.; Michigan; Wisconsin.

43. *Corymbites aeripennis* Kby. One taken at Scovill Point (IV, 1) on July 19 (G. 130).

Geographic Range. Ottawa, Canada; Nova Scotia; Maine; Mt. Washington, N. H.; New York; Mich.; Wis.; Colo.; New Mexico; Idaho; Oregon; Brit. Columbia.

44. *Corymbites aratus* Lec. On July 19 one was taken at Tobin Harbor (A. 29).

Geographic Range. Canada; Lake Superior; Michigan; No. Wisconsin.

Buprestidae.

45. *Dicera prolongata* Lec. A. Two were taken about camp at the Light-house (I, 7) on July 10 (G. 45) and on July 15 (G. 86).

Geographic Range. Saskatchewan basin; Ottawa, Canada; New Hampshire; Mass.; New Jersey; Mich.; Wisconsin; Nebraska; Kansas; Colo.; New Mexico; Idaho.

46. *Dicera tenebrosa* Kby. Taken about the camps at the Light-house (I, 7) on July 25 (G. 153), and at Siskowit Bay (V, 3) on August 7 (G. 212), and 15 (G. 239).

Geographic Range. Ottawa, Canada; Lake Superior; Mt. Washington, N. H.; Mass.; Mich.; Duluth, Minn. (Wolcott); Wisconsin; Colorado.

47. *Buprestis maculiventris* Say. A. This was the most abundant species of the family, and was very abundant about the camp on Siskowit Bay (V, 3) during August; others were taken at the Light-house clearing (I, 7) during July (G. 86, 117, 179, 195, 212, 222, 231), (A. 152).

Food plants. Beetles have been found on balsam and spruce, and emerging from pine timber. (Felt, 1906, p. 674.)

Geographic Range. Newfoundland; Ottawa, Canada; Lake Superior region; Mt. Washington (summit), N. H.; Vermont; Mass.; New York;

Penna.; Mich.; Wisconsin; Nebraska; Kansas; Colo.; New Mexico; Utah. (Washington; Oregon, cf. Bethune, '76, p. 65).

48. *Buprestis fasciata* Fab. (and varieties). Like the preceding species, this was also taken in large numbers; at the Light-house (1, 7) during July and at camp on Siskowit Bay (V, 3) during August. (G. 117, 133, 153, 166, 195, 212, 231). This is a large metallic green species which shows considerable variation in the amount of the light-colored spots on the elytra. In some Isle Royale specimens the spots are well developed, in others completely lacking. The var. *langii* is credited to Isle Royale in the Hubbard and Schwarz list ('78). This is a western and northwestern variety, Alaska, Brit. Columbia and western mountains.

Food plants. Found on poplars, and the larva bores in maple. (Felt, '06, p. 459.)

Geographic Range. Ottawa, Canada; Nova Scotia; Northeastern U. S. generally; W. Penna.; Ohio (Dury); Michigan; Wisconsin; Colorado.

49. *Buprestis striata* Fab. A. Taken on the open rock ridge north of the Light-house (I, 2) on July 13 (G. 68). One specimen.

Food plants. Occurs on pine and spruce, the buds of which the beetles are said to eat; may also feed upon dead wood. (Felt, '06, p. 655).

Geographic Range. Ottawa, Canada; New York; Mass.; New Jersey; Penna.; Ohio (Dury); Michigan; Wisconsin.

50. *Melanophila accuminata* DeG.-*longipes* Say. A. Two specimens were taken at the Light-house (1, 7) on July 7 (G. 26) and on July 11 (G. 49).

Geographic Range. Canada; Hudson Bay south to Virginia, and Kentucky; W. Penna.; Mich.; Wisconsin; Colo.; New Mexico; So. Calif.; Brit. Columbia; Alaska; Europe; China.

51. *Melanophila drummondi* Kby.=*guttulata* Gebl. A. Taken about the camps at the Light-house (I, 7) during July (G. 98), and on Siskowit Bay (V, 3) during August (G. 212, 231, 239). Five specimens.

Food plant. Found on spruce logs. (Blanchard, Ent. Amer., 5, p. 30).

Geographic Range. Maine to Alaska (Yukon); Mt. Washington (summit), N. H.; Mich.; Wisconsin; Idaho; Colo.; New Mexico; Utah; Calif.; Washington; Oregon; Alaska; Siberia. Hamilton, '94, p. 29, '94a, 391.

52. *Chrysobothris trinervia* Kby. Found at the Light-house (I, 7) during July (G. 166) and very abundant at the camp on Siskowit Bay (V, 3) during August (G. 212, 222,231, 239).

Food plant. Found on spruce logs. Blanchard, Ent. Amer., 5, p. 31.

Geographic Range. Lake Winnipeg; Alberta; Hudson Bay region; Ottawa, Ontario; N. H.; W. Penna.; North Carolina; Mich.; Colo.; New Mexico; Washington; Oregon. Hamilton, '94, p. 29.

53. *Agrilus acutipennis* Mann. A. One specimen from the clearing at the Light-house (I, 7) on July 26 (G. 166).

Food plant. Found on Oak. Blanchard, Ent. Amer., 5, p. 32.

Geographic Range. "Mass. to Kansas, Florida and Texas"; W. Penna.; Ohio (Dury); Mich.; Glendon Park, Ill. (Wolcott). Horn, Trans. Am. Ent. Soc., 18, p. 309.

Lampyridae.

54. *Podabrius diadema* Fab. A. Found about the camp at the Lighthouse (I, 7) on July 23 (G. 133), and among beach drift at the head of Tonkin Bay (I, 1) on July 7 (A. 7). Two specimens.

Geographic Range. Ottawa, Canada; Mt. Washington, N. .H; Vermont; New York; New Jersey; W. Penna.; Mich.; Wisconsin; Iowa.

55. *Podabrus tomentosus* Say. A. Taken at the camp on Siskowit Bay (V, 3) on August 4 (G. 201).

Geographic Range. W. Penna.; Mich.; Illinois (Wolcott); Colorado.

56. *Malthodes niger* Lec. Found in a small rock pool on the Lake shore (I, 1) on July 12 (G. 75).

Geographic Range. Isle Royale, Marquette, Mich.; Lake Superior region; Mt. Washington, N. H.

Scarabaeidae.

57. *Geotrupes blackburnii* Fab. A. Two of these beetles were taken about horse dung on the Desor trail (III, '04) on August 21 (A. 143).

Geographic Range. Ottawa, Canada; New York; New Jersey; Dist. Columbia; Ohio; Mich.; Wis.

58. *Serica vespertina* Gyll. A. One specimen found on the gravelly beach near the Light-house (I, 1) on July 10 (G. 43).

Geographic Range. Ottawa, Canada; Nova Scotia; Saskatchewan basin; Vermont; New York; N. J.; Dist. Columbia; Fla.; W. Penna.; Ohio; Mich.; No. Illinois and Indiana (Wolcott); Wisconsin; Iowa; Nebraska; Kansas; Colorado; New Mexico.

59. *Diplotaxis liberta* Germ. A. A single dead specimen (G. 102) was found under a flat rock on a jack pine ridge (I, 5).

Geographic Range. Isle Royale, Mich; W. Penna.; New Jersey; Dist. of Col.

60. *Lachnosterna arcuata* Smith. A. Taken at the Light-house camp (I, 7), on July 26 (G. 166).

Geographic Range. W. Penna.; Dist. Columbia; Michigan; Elliot and Carbondale, Ill. (Wolcott).

61. *Trichius affinis* Gory. Very abundant in the flowers of the Cow Parsnip (*Heracleum lanatum*) in the clearing at the Light-house (I, 7) during July (G. 26, 45, 49, 105, 133, 136, 137).

Geographic Range. Saskatchewan basin; Ottawa, Canada; Nova Scotia; N. H.; New York; New Jersey; Virginia; W. Penna.: Ohio. Mich.; No. Illinois (Wolcott); Wisconsin; Iowa; Colorado; New Mexico.

Cerambycidae.

62. *Phymatodes variabilis* Fab. A. Two specimens were taken on Siskowit Bay (V, 3) on August 15 (G. 239) and August 16 (A. 152).

Food plants. Larva feeds on the inner bark of dead and dying oaks and hickory. Probably has other food plant as hickory was not found on the island and oak is of very rare occurrence. (Felt, '06, p. 433.)

Geographic Range. Mass. to Alabama; W. Penna.; Ohio (Dury); New York; Mich.; Wisconsin; Kansas; Colorado; Arizona. Hamilton, '97a, p. 395. Probably introduced.

63. *Xylotrechus undulatus* Say. This active beetle was exceedingly

abundant about the camps at the Light-house (I, 7) during July and on Siskowit Bay (V, 3) during August. There is considerable variation in the yellow elytral markings in the series secured. (G. 86, 212, 222, 231, 239), (A. 5, 152).

Food plants. Has been found on hemlock and spruce, but as hemlock is not found on the island, spruce is probably the food plant. (Felt, '06, p. 671).

Geographic Range. Ottawa, Canada; Lake Superior; New Hampshire; New York; New Jersey; W. Penna.; Mich.; Wisconsin; Iowa; Nebr.; Kansas; New Mexico; Northwest Terr.; Colorado; British Columbia.

64. *Pachyta liturata* Kby. A. The one specimen is from the camp at Rock Harbor (1, 7) on July 31 (G. 191).

Geographic Range. Vermont; Hudson Bay region; Mich.; Colo.; New Mexico (Psyche 9, p. 303); Washington; Idaho; British Col. Hamilton, '94, p. 31.

65. *Acmacops proteus* Kby. One taken at the Siskowit camp (V, 3) on August 15 (G. 239).

Geographic Range. Labrador; Ottawa, Ontario; "common through Canada;" Hudson Bay; Saskatchewan basin; Mt. Washington (summit), N. H.; Mass.; New York; Mich.; Wisconsin; Kansas; New Mexico; Montana; Colo.; Oregon; Brit. Columbia.

66. *Bellamira scalaris* Say. A. A single specimen of this slender beetle came from the Light-house camp (1, 7) on July 22 (G. 133).

Food plants. Beetle and larva have been found under the bark of the Yellow Birch. (*B. lutea*) and has been found ovipositing on maple. (Beutenmuller, '96, p. 77.)

Geographic Range. Saskatchewan basin; Ottawa, Canada; N. H.; New York; W. Penna.; New Jersey; Maryland; Va.; La.; Ohio (Dury); Mich.; Wisconsin.

67. *Leptura subargentata* Kby. One specimen from the Light-house camp (1, 7) on July 11 (G. 49).

Geographic Range. Canada; Hudson Bay and Lake Superior region; N. H.; Mass.; New York; Dist. Columbia; Georgia; Mich.; Ohio (Dury); Wisconsin; Montana; Colo.; New Mexico; Nevada; Utah; Calif.; Washington; Brit. Columbia; Alaska.

68. *Leptura nigrella* Say A. A single specimen was taken at the Siskowit camp (V, 3) on August 7 (G. 212).

Geographic Range. Ottawa, Canada; Hudson Bay region; Maine; Georgia; W. Penna.; Mich.; No. Illinois (Wolcott); Wisconsin; Colo.; New Mexico; Nevada; Washington.

69. *Leptura sexmaculata* L. A. Taken on the flowers of the Cow Parsnip in the clearing at the Light-house (1, 7) during July (G. 105).

Geographic Range. Hudson Bay to Lake Superior; Ottawa, Canada; Quebec; Mt. Washington (summit), N. H.; Mich.; Wisconsin; Colo.; Brit. Columbia; eastern and western Siberia; Alps and Europe. Hamilton, '94, p. 396.

70. *Leptura canadensis* Fab. A. Only two specimens of this red shouldered beetle were taken, one from the camp on Siskowit (V, 3) on August 7 (G. 212), and the other on August 13 (G. 232) from near the head of Siskowit Bay (VIII, '04).

Food plants. Larva burrows in spruce and hemlock. (Beutenmuller, '96, p. 78).

Geographic Range. Ottawa, Can.; Nova Scotia; N. H.; Vermont; Mass.; New York; Penna.; Virginia; Ga.; Mich.; Wisconsin; Mo.; Colo.; New Mexico; No. Arizona; No. Idaho; Brit. Columbia; eastern and western Siberia; Japan; Russia; Germany. Hamilton, '94a, p. 396.

71. *Leptura chrysocoma* Kby. This bright yellow beetle was the most abundant Cerambycid, occurring in great numbers in the flowers of the Cow Parsnip in the clearing at the Light-house (1, 7); also found in the flowers of the Wild Rose on the beach (I, 1); and on the flowers of *Opulaster opulifolius*, at the mouth of Benson brook (II, 1) during July. Also taken at the Siskowit camp (V, 3) on August 5. (G. 37, 45, 49, 105, 133, 137, 148, 191.)

Geographic Range. Ottawa, Can.; Hudson Bay region; Nova Scotia; Maine; N. H.; New York; Mich.; Wisconsin; Colo.; New Mexico; No. Arizona; Priest's Lake, Idaho, (Wolcott); Utah; Nevada; Calif.; Brit. Columbia.

72. *Leptura proxima* Say. A. Two specimens were found on the flowers of the Cow Parsnip (I, 7) in July (G. 105, 179), and another specimen at the camp on Siskowit Bay (V, 3) on August 3 (G. 195).

Food plant. Reared from maple. (Wickham. Can. Ent., 29, p. 192.)

Geographic Range. Ottawa, Can.; Vermont; N. H.; Mass.; New York; W. Penna.; Virginia; Ga.; Dist. of Columbia; Ohio; Mich.; No. Ill. (Wolcott); Wisconsin; Iowa; Missouri.

73. *Leptura tibialis* Lec. A. The one specimen is from the camp on Siskowit Bay (V, 3) on August 16 (A. 152).

Geographic Range. Mt. Washington, New Hampshire; Michigan; Oregon.

74. *Leptura mutabilis* Newm. Four specimens were taken at the Light-house (I, 7) during July (G. 49, 105, 137, 166). Some of these were taken on the flowers of the Cow Parsnip.

Geographic Range. Saskatchewan basin; Ottawa, Can.; Mt. Washington (summit), N. H.; New York; Dist. Columbia; Mass.; New Jersey; W. Penna.; Ohio (Dury); Mich.; Wisconsin; New Mexico.

75. *Monohammus scutellatus* Say. A. Six specimens of these large beetles were taken: one at the Light-house (I, 7) on July 24 (G. 152), and the others on August 7, 12 and 16 at the Siskowit camp (V, 3). (G. 212, 231; A. 152).

Food plant. Taken on white and hard pine; beetle girdles branches and the larva bores in spruce trunk. (Felt, '06, p. 364.)

Geographic Range. Ottawa, Can.; Hudson Bay region; Saskatchewan basin; W. Penna.; St. Joseph (Wolcott), Isle Royale, Mich.; Wisconsin; Duluth, Minn. (Wolcott); Colo.; New Mexico; Brit. Columbia; Alaska; extensive N. American range in "pine regions." District of Columbia.

*Chrysomelidae.**

76. *Donacia proxima* Kby. A. "In the water-lily zone of Sumner Lake (III, 5) on July 27 (G. 171). The beetles fly low, dragging the tip of the abdomen in the water, and apparently alight only on leaves of the waterlily." Gleason. Also taken July 29 (A. 184).

* cf. Chittenden ('93) for food habits of this family.

Geographic Range. Ottawa, Can.; Lake Superior; N. H.; Mass.; New York; Penna.; Mich.; Wis.; Hudson Bay Terr.; Idaho; Calif. Leng. Trans. Am. Ent. Soc., 18, p. 167.

77. *Donacia cincticornis* Newm. A. "Three specimens were taken on July 27 and 28 at Sumner Lake (III, 5), associated with the preceding species and with the same habit." Gleason. (G. 171, 175).

Geographic Range. Canada; Vermont; New Hampshire; Mass.; New York; Michigan; No. Illinois; Texas.

78. *Orsodachna atra* Ahr. var.=*childreni* Kby. Two specimens were taken at the Light-house (I, 7) on July 11 (G. 49). Horn. Tr. Am. Ent. Soc., '92, pp. 6-7. Ent. Amer., I, p. 9.

Geographic Range. Saskatchewan basin; Ottawa, Canada; New England and south on the mountains to N. Carolina; W. Penna.; Mich.; Wisconsin; No. Ill. (Wolcott); Iowa; Alberta; Colorado; New Mexico; Arizona; California. Psyche, 9, p. 303; Brit. Columbia.

79. *Galerucella nymphaea* L. A. These leaf beetles were taken in a small bayou (IV, 3) connected with Tobin Harbor on July 21 (A. 42). Larvae, pupae, freshly emerged and fully covered adults were all represented in very large numbers. The lily leaves were riddled by the innumerable larvae. Cf. Chittenden, '05, p. 58 and Mac Gillivray, '03, p. 325 for the life history of this species.

Geographic Range. In Canada westward to the Mackenzie Basin and into Alaska; New York; Va.; Ohio (Dury); W. Penna.; Mich.; Colorado; Texas; Oregon; Calif.; Siberia into Europe. Hamilton, '94a, p. 398.

Tenebrionidae.

80. *Upis ceramboides* L. A. A single specimen was taken at the Light-house (I, 7) on July 23 (G. 153).

Geographic Range. Ottawa, Can.; Hudson Bay; Saskatchewan basin; Lake Superior; Nova Scotia; Maine; Mt Washington, N. H.; Vermont; New York; New Jersey; W. Penna.; Mich.; Wisconsin; Estherville, Cass Co., Minn. (Wolcott); Colo.; Montana; Manitoba; No. Asia; Siberia; No. Europe; Germany. Hamilton, '94a, p. 400.

Cistelidae.

81. *Cistela sericea* Say. A. Found under loose stones on the jack pine ridge (I, 5) on July 14 (G. 81).

Food plants. Has been found on pine, oak and basswood. (Felt, '06, p. 518.)

Geographic Range. Michigan; W. Penna.; New Jersey; New Mexico.

Melandryidae.

82. *Serropalpus barbatus* Schall. A. One specimen was taken at Tobin Harbor on July 19 (G. 129).

Food plant. Larva bores in sap and heart wood of balsam and spruce. (Felt, '06, p. 671).

Geographic Range. Canada; Lake Superior and Hudson Bay regions; Maine; Vermont; New York; W. Penna.; West Virginia; Colorado; Rocky Mts. south to New Mexico; Manitoba; Oregon; Brit. Columbia; Alaska; Siberia; Europe.

Mordellidae.

83. *Anaspis rufa* Say. A. Many specimens of this species were taken about the camp at the Lighthouse (I, 7) on July 28 (G. 179).

Geographic Range. Ottawa, Can.; Mt. Washington (summit), N. H.; Vermont; New York; New Jersey; Dist. Col.; Florida; Ohio; Michigan; Wisconsin; Wyoming; Colo.; Utah; Lower Calif.; New Mexico; Mexico; Washington; Brit. Columbia; Alaska.

84. *Mordellistena biplagiata* Helm. A. One specimen was taken on flowers in the clearing at the Lighthouse (I, 7) on July 11 (G. 49).

Geographic Range. New York; Dist. of Columbia; Ohio; Mich.; Illinois; Wis.

85. *Mordellistena scapularis* Say. A. Two specimens were taken at the Lighthouse (I, 7) on July 28 (G. 179).

Geographic Range. Dist. of Columbia; "Middle and Western States"; Mich. (Isle Royale); Ottawa, Canada.

Curculionidae.

86. *Hylobius pales* Hbst. A. A single specimen was taken at the Lighthouse (I, 7) on July 13 (G. 86).

Food plant. Larvae live in bark of white pines. (Felt, '06, p. 664).

Geographic Range. Ottawa, Canada; Maine to Florida; Michigan; W. Penna.; Duluth, Minn. (Wolcott).

87. *Hypomolyx pineti* Fab. A. This large snout beetle (G. 179) was taken July 28 in the Lighthouse clearing (I, 7).

Geographic Range. Canada; Hudson Bay region; Saskatchewan basin; Mich.; Wisconsin; Siberia; Europe.

88. *Magdalis.* "Apparently new," Wickham.; Taken at the Lighthouse camp (I, 7) on July 23 (G. 136), at Siskowit (V, 3) on August 15 (G. 239).

Calandridae.

89. *Cossonus subarcatus* Boh. A. Taken at the Siskowit Camp (V, 3) on August 7 (G. 212).

Geographic Range. Mt. Washington, N. H.; Michigan; Wisconsin; Glendon Park, Ill. (Wolcott); Iowa; Kansas; Nebraska; Colorado; New Mexico; "Middle States."

2. *SUPPLEMENTARY LIST OF ISLE ROYALE BEETLES.*

BY A. B. WOLCOTT.

Field Museum of Natural History, Chicago.

This supplementary list of species records from Isle Royale all the species taken by Hubbard and Schwarz ('78, pp. 627-643) but not found in the 1905 collections. These two lists make a complete catalog of the species so far found on this island, excepting those species which are scattered in the literature and have thus been overlooked. The general geographic range of each species is given.

Carabidae.

1. *Bembidium concolor* Kby. New York; Maine; Canada; Michigan (Michipicoton River); Wyoming; Maine to the Pacific coast.
2. *Bembidium planatum* Lec. Michigan (Isle Royale); Colorado; Wyoming; Nevada; Oregon; Washington to British Columbia.
3. *Patrobius longicornis* Say. New Jersey; Vermont; New York; Dist. Columbia; Ohio; Pennsylvania; Canada; Michigan (Escanaba); Wisconsin; Illinois; Indiana; Iowa; Colorado; Texas; New Mexico.
4. *Pterostichus punctatissimus* Rand. Massachusetts; New Hampshire; Vermont; Maine; Canada; Hudson Bay region; Michigan (Michipicoton Island); Arctic Sibera; the Amur; Dauria.
5. *Pterostichus mandibularis* Kby. var. New Hampshire; Vermont; Massachusetts; Canada; Wisconsin; Michigan (Marquette, Michipicoton River); Hudson Bay region; Alaska; Arctic Siberia.
6. *Amara latior* Kby. New Jersey; New Hampshire; Canada; Michigan (Escanaba, Ann Arbor); Wisconsin; Illinois; Nebraska; Colorado; Idaho; New Mexico; Arizona; Vancouver Island.
7. *Amara impuncticollis* Say. Dist. Columbia; Ohio; Michigan (Detroit); Wisconsin; Canada; Montana; Colorado; New Mexico.
8. *Calathus advena* var. *mollis* Mots. Vermont; Maine; Michigan (Michipicoton River, Michipicoton Island); Alaska.
9. *Platynus aeruginosus* Dej. Dist. Columbia; Indiana (Pine); Illinois (Chicago); Michigan (Escanaba, Detroit); Wisconsin.
10. *Dromius piceus* Dej. New Jersey; New York; Dist. Columbia; Massachusetts; Ohio; Michigan (Marquette, Detroit); Wisconsin; Canada; Iowa; California.
11. *Harpalus fulvilabris* Mann. Michigan (Marquette, Michipicoton River).
12. *Harpalus rufimanus* Lec. Michigan (Escanaba, Marquette); Wisconsin; Canada; British Columbia.
13. *Harpalus laticeps* Lec. New Hampshire (Summit Mt. Washington); Michigan (Escanaba, Marquette, Lake Huron); Wisconsin; Canada (Ottawa); Colorado.
14. *Bradycellus cordicollis* Lec. New Hampshire (Mt. Washington); Michigan (Marquette).

Hydrophilidae.

15. *Crenophilus* (*Hydrobius*) *digestus* Lec. Michigan (Marquette, Detroit).

Silphidae.

16. *Necrophorus vespilloides* Hbst. New Jersey; New Hampshire (Mt. Washington); Michigan (Escanaba, Michipicoton Island); Wisconsin; Hudson Bay Territory; Nova Scotia; Ontario; Manitoba; British Columbia; Alaska; Washington; Oregon; East Siberia; Kamtschatka; Amurland; Europe; China.

17. *Choleva basillaris* Say. New Jersey; New Hampshire (Mt. Washington); Ohio; Michigan (Sault de Ste. Marie, Detroit); Wisconsin; Nebraska; Kansas; Canada; Hudson Bay Territory; British Columbia; Alaska; Nevada to Colorado; California.

18. *Choleva* (*Catops*) *terminans* Lec. Virginia; New Jersey; Massachusetts; Dist. Columbia; Ohio; Illinois; Michigan (Bachewanung Bay, Michipicoton Island); Wisconsin; Canada (Ottawa).

19. *Anistoma assimilis* Lec. Dist. Columbia; New Hampshire (Summit Mt. Washington); Michigan (Marquette, Michipicoton River); Wisconsin; Canada; Colorado; Vancouver Island.

20. *Liodes globosa* Lec. New Hampshire (Mt. Washington); Michigan (Marquette); Canada (Ottawa); Colorado; New Mexico.

21. *Agathidium revolvens* Lec. Canada (Ottawa); British Columbia; New Mexico.

22. *Clambus gibbulus* Lec. Florida; Dist. Columbia; Michigan (Marquette, Detroit); Colorado; S. Arizona.

Pselaphidae.

23. *Tychus longipalpus* Lec. Florida; Dist. Columbia; Michigan (Marquette); Canada (Ottawa).

24. *Reichenbachia* (*Bryaxis*) *propinqua* Lec. Canada (Ottawa); Michigan (Marquette, Point aux Pins); Colorado (species doubtfully identical).

Staphylinidae.

25. *Quedius laevigatus* Gyll. Georgia; New Hampshire (summit Mt. Washington); Massachusetts; Pennsylvania; Ohio; Illinois; Michigan (Marquette, Bachewanung Bay, Detroit); Canada; British Columbia; Alaska; Oregon; Nevada; Colorado; Kansas; New Mexico; California; eastern Siberia; northern and Alpine Europe.

26. *Stenus semicolon* Lec. Dist. Columbia; Michigan (Escanaba, Marquette, Bashewanung Bay, Michipicoton River).

27. *Lathrobium terminatum* Grav. (*punctulatum* Lec.). Florida; Georgia; Dist. Columbia; New Jersey; W. Pennsylvania; Ohio; "Eastern States"; Massachusetts; Michigan (Escanaba, Marquette, Detroit); Wisconsin; Iowa; Canada; Kansas; Colorado; Europe and Siberia.

28. *Tachinus fumipennis* Say. Florida; Dist. Columbia; Michigan (Marquette); Wisconsin: Colorado.

29. *Bolitobius cingulatus* Mann. Virginia; New Jersey; New Hampshire (Mt. Washington); Pennsylvania; Michigan (Sault de Ste. Marie,

Bachewanung Bay, Detroit); Wisconsin; Canada; Oregon; Queen Charlotte Island; British Columbia; Alaska; Caucasia; Europe.

30. *Hobrocerus magnus* Lec. Michigan (Marquette). The type of this species came from Isle Royale.

31. *Olisthaerus megacephalus* Zett. Michigan (Michipicoton Island); Canada; Alaska; California; Siberia; Lapland; Sweden; Hungary; Arctic and Eastern Siberia.

32. *Olisthaerus substriatus* Payk. (*nitidus* Lec.). Massachusetts; Michigan (Michipicoton, Eagle Harbor); Wisconsin; Sweden; Germany; France; Arctic and Eastern Siberia.

33. *Ancyrophorus planus* Lec. New Hampshire (Mt. Washington); Michigan (Isle Royale).

34. *Anthophagus verticalis* Say. Michigan (Marquette, Detroit).

35. *Acidota creanta* Fabr. (*seriata* Lec.). Massachusetts; Common on Islands and shores of Lake Superior; Michigan (Marquette, Michipicoton River, Detroit); Canada; central and northern Europe; Siberia.

36. *Arpedium* sp. Michigan (Marquette).

Phalacridae.

37. *Phalacrus politus* Melsh. Florida; Dist. Columbia; Ohio; Illinois; Michigan (Marquette, Detroit); Canada (Ottawa); Iowa; Colorado.

Coccinellidae.

38. *Coccinella perplexa* Muls. (*trifasciata* Linn.). New York; New Hampshire (Mt. Washington); Canada; Hudson Bay Territory; Michigan (Detroit, Marquette, Au Train Falls, St. Joseph); Wisconsin; Illinois (Chicago, taken by Wolcott); Alaska; Vancouver Island; Oregon; Washington to California; New Mexico; Kamtschatka through northern Siberia and Europe to Lapland. Circumpolar.

39. *Coccinella transversoguttata* Fald. var. *transversalis* Muls. The typical form or its varieties are known from New Hampshire (summit Mt. Washington); Greenland; Hudson Bay region; various places in Canada; British Columbia; Northwest Territory; Alaska; Illinois (Chicago, Wolcott coll.); Michigan (Bachewanung Bay, Chatham; Wisconsin; Minnesota (Duluth, Wolcott coll.); Nebraska; Nevada; Colorado; New Mexico; California; Rocky Mountains and Pacific regions to mountainous Mexico; eastern Siberia; Japan; northern China; Dauria; Lapland. Circumpolar.

40. *Cycloneda sanguinea* Linn. Florida; West Indies; "United States and Canada generally"; Michigan (Michipicoton River, Chatham); Wisconsin; Illinois; Indiana; Ohio; New Jersey to Colorado; New Mexico; N. Arizona; Texas; Baja California; Europe.

41. *Cleis* (*Harmonia*) *picta* Rand. Dist. Columbia; Pennsylvania; Canada to Colorado; New Hampshire (summit Mt. Washington); Michigan (Escanaba, Marquette); Minnesota (Duluth, Wolcott coll.); New Mexico.

42. *Scymnus lacustris* Lec. Michigan (Escanaba, Marquette); Colorado; Arizona.

Endomychidae.

43. *Lycoperdina ferruginea* Lec. Dist. Columbia; New Jersey west to Colorado; New Hampshire (Mt. Washington); New York; "Middle and Southern States"; Ohio; Illinois (central and northern); Michigan (Bachewanung Bay, Detroit); Canada; Wisconsin; Iowa; Colorado; New Mexico.

Histeridae.

44. *Hister basalis* Lec. Ohio: Michigan (Marquette).
45. *Plegaderus sayi* Mars. "Middle States"; Michigan (Sault de Ste. Marie, Marquette); Canada; Wisconsin; Colorado; New Mexico.

Nitidulidae.

46. *Omosita' discoidea* Fabr. Canada; Michigan (northern); Colorado; New Mexico; Europe and the Pacific States, east to Colorado.

Lathridiidae.

47. *Stephostethus (Lathridus) liratus* Lec. Dist. Columbia; Ohio; Canada (Ottawa); Michigan (Detroit); Queen Charlotte Islands, British Columbia.
48. *Lathridius minutus* Linn. "Nearly all North America"; Dist. Columbia; Michigan (Detroit); Wisconsin; Colorado; "Alaska to Louisiana and to Massachusetts and eastern Canada"; all Europe and northern Asia to Kamtschatka.
49. *Corticaria serricollis* Lec. Michigan (Michipicoton River, Detroit); British Columbia.

Byrrhidae.

50. *Byrrhus geminatus* Lec. New Hampshire (summit Mt. Washington); Michigan (Isle Royale only).

Dascyllidae.

51. *Macropogon piceus* Lec. Michigan (Isle Royale only).
52. *Eurypogon niger.* Michigan (Michipicoton River).
53. *Euscinetus terminalis* Lec. New Jersey west to Colorado; New York; Vermont; Ohio; Illinois; Michigan (Escanaba, Marquette, Detroit); Canada.

Elateridae.

54. *Cryptohypnus bicolor* Esch. This species is believed to be merely a variety of *nocturnus* Esch. which is recorded with the variety from the following localities;—Labrador; Hudson Bay regions; New Hampshire (summit and alpine regions Mt. Washington); Canada; Michigan (Marquette, Sault de Ste. Marie); Dakota; Wisconsin; Utah; Colorado; Montana; Idaho; New Mexico; Oregon; British Columbia; Alaska; Kamtschatka; eastern Siberia.
55. *Crytohypnus tumescens* Lec. Michigan (Sault de Ste. Marie); Colorado; New Mexico.
56. *Elater nigrinus* Payk. var.? *Elater nigrinus* occurs in Vermont; Canada (Ottawa); Michigan (Escanaba, Marquette, Detroit); Alaska;

Vancouver Island and Queen Charlotte Island; British Columbia; New Mexico; northern and central Europe; west Siberia; Amurland.

57. *Elater mixtus* Hbst. Dist. Columbia; New Hampshire (summit Mt. Washington); Canada (Ottawa); Michigan (Marquette, Michipicoton Island); Colorado.

58. *Betarmon bigeminatus* Rand. Dist. Columbia; Canada (Ottawa); Michigan (Marquette).

59. *Melanotus Leonardi* Lec. Michigan (Marquette, Detroit).

60. *Melanotus castanipes* Payk. (*scrobicollis* Lec.). "Middle States to Canada"; New York; Vermont; New Hampshire (summit Mt. Washington); Dist. Columbia; Ohio; Pennsylvania; Canada; Michigan (Escanaba, Marquette, Detroit); Wisconsin; Colorado; Europe; West Siberia; Amurland.

61. *Limonus aeger* Lec. New Jersey; New Hampshire (Mt. Washington); Canada (Ottawa); Michigan (Marquette); Wisconsin.

62. *Campylus denticornis* Kirby. New Hampshire (summit Mt. Washington); Maine; Pennsylvania; Canada (Ottawa); Ohio; Michigan; (Marquette, Port Huron); Wisconsin.

63. *Paranomus costalis* Payk. New Hampshire (summit Mt. Washington); "The northern shore of Lake Superior"; Labrador; Europe (Sweden, Finland, Lapland); Amurland.

64. *Sericosomus incongruus* Lec. Canada (Ottawa); Michigan (Marquette); New Hampshire (Mt. Washington).

65. *Corymbites resplendens* Esch. Newfoundland; Maine; Lake Superior region northward to 56°; Vermont; Canada (Ottawa); Michigan (Michipicoton Island, Marquette); New Hampshire (summit Mt. Washington); Wisconsin; Queen Charlotte Island; British Columbia; Alaska.

66. *Corymbites spinosus* Lec. New Hampshire (summit Mt. Washington); Canada (Ottawa); Michigan (Escanaba, Marquette); Wisconsin; Iowa.

67. *Corymbites mendax* Lec. Michigan (Eagle Harbor).

68. *Corymbites insidiosus* Lec. New Hampshire (Mt. Washington); Michigan (Marquette).

69. *Corymbites falsificus* Lec. New Hampshire (summit Mt. Washington); Canada; Michigan (Marquette); Wisconsin.

70. *Corymbites triundulatus* Rand. New Hampshire (summit Mt. Washington); Maine; Vermont; Michigan (Marquette); Canada (Ottawa); Wisconsin; Colorado.

71. *Corymbites propola* Lec. New York; Vermont; New Hampshire (summit Mt. Washington); Canada; Michigan (Michipicoton River, Marquette); British Columbia.

72. *Corymbites nigricollis* Bland. Michigan (Marquette); Colorado.

73. *Corymbites splendens* Ziegl. Dist. Columbia; Ohio; Canada (Ottawa); Michigan (Marquette).

74. *Corymbites nigricornis* Panz. New Jersey; New Hampshire (summit Mt. Washington); Massachusetts; Illinois (Ft. Sheridan, Wolcott); Michigan (Marquette, Detroit); Canada; Iowa; Wisconsin; Colorado; central and boreal Europe and Siberia.

Buprestidae.

75. *Melanophila fulvoguttata* Harr. New Hampshire (summit Mt. Washington); Canada (Ottawa); Michigan (Escanaba, Marquette, Port Huron); Kansas.

Lampyridae.

76. *Plateros (Eros) modestus* Say. Florida; Dist. Columbia; New Hampshire (summit Mt. Washington); Ohio; Michigan (Detroit, Marquette); Canada (Ottawa); Iowa (McGregor, Wolcott); New Mexico.

77. *Ellychnia (Photinus) corrusca* Linn. "Common in Canada and most of the United States east of the Rocky Mountains"; Dist. Columbia; Virginia; Georgia; New Jersey; New Hampshire (summit Mt. Washington); New York; Ohio; Indiana (Wolcott); Illinois; Michigan (Michipicoton River, Detroit); Iowa; Wisconsin; Nebraska; Kansas; Colorado; New Mexico; Arizona; Canada (Ottawa); Nova Scotia; Northwest Territory.

78. *Podabrus modestus* Say. Georgia; New Jersey; New York; New Hampshire (Mt. Washington); Pennsylvania; Ohio; Michigan (Escanaba, Marquette, Detroit); Canada (Ottawa); Iowa; Wisconsin; Colorado.

79. *Podabrus laevicollis* Kby. New Hampshire (Mt. Washington); Michigan (Marquette, Michipicoton River); Colorado.

80. *Telephorus Curtisii* Kby. New Hampshire (summit Mt. Washington); Michigan (Marquette, Michipicoton River); Wisconsin; Iowa; Hudson Bay region; British Columbia.

81. *Malthodes laticollis* Lec. (*transversus* Lec.). Michigan (Isle Royale only).

82. *Malthodes concavus* Lec. Dist. Columbia; Michigan (Marquette, Detroit); Colorado.

83. *Malthodes fragilis* Lec. Michigan (Detroit).

Cleridae.

84. *Thanasimus (Clerus) undatulus* Say. New York; Vermont; Maine; New Hampshire (summit Mt. Washington); Canada; Michigan (Marquette, Escanaba); Minnesota; Hudson Bay north to lat. 65°; Kansas; Colorado; New Mexico; variety *nubilus* occurs in Northwest Territory and Alaska.

Ptinidae.

85. *Dinoderus substriatus* Payk. New Hampshire (summit Mt. Washington); "Northern States"; Canada; Pennsylvania; Michigan (Escanaba, Marquette, Bachewanung Bay); Alaska; eastern and western Siberia; Europe.

Cioidae.

86. *Cis creberrimus* Mellié. Florida; Dist. Columbia; Ohio; Michigan (Marquette, Detroit).

Cerambycidae.

87. *Tetropium cinnamopterum* Kirby. New Jersey; New Hampshire (summit Mt. Washington); Vermont; Pennsylvania; Canada; Michigan (Marquette); Wisconsin; Colorado; New Mexico; northern and mountainous Arizona; California; Oregon; Washington; Northwest Territory; British Columbia; Alaska; "north to 55°".

88. *Phymatodes maculicollis* Lec. New Hampshire (Mt. Washington); Michigan (Isle Royale-type locality); Colorado (7-9000 ft. el.).

89. *Microclytus gazellula* Hald. (*Crytophorus gibbulus* Lec.). Dist. Columbia; New Hampshire (Mt. Washington); Canada (Ottawa); Michigan (Detroit).

90. *Pachyta monticola* Rand. New York; New Hampshire (summit Mt. Washington); Vermont; Maine; Massachusetts; Pennsylvania; Michigan (Marquette); Wisconsin; Canada (Ottawa); Anticosti Island; Alaska.

91. *Leptura rufula* Hald. Michigan (Isle Royale only).

92. *Pogonocherus mixtus* Hald. Dist. Columbia; New Jersey; New York; New Hampshire (summit Mt. Washington); Indiana (Clarke Junction, Dune Park, Wolcott coll.); Canada; Michigan (North Muskegon, Marquette, Michipicoton River, Port Huron); Kansas; New Mexico; Colorado; Northern Arizona.

Chrysomelidae.

93. *Zeugophora varians* Cr. New Jersey; New Hampshire; Pennsylvania; Indiana (Pine-Wolcott coll.); Illinois (Glen Ellyn, Wolcott coll.); Canada; Michigan (Detroit); Wisconsin; Kansas; Washington.

94. *Syneta ferruginea* Germ. Dist. Columbia; Maryland; New Jersey; New York; New Hampshire (Mt. Washington); Vermont; Massachusetts; Ohio; Illinois (central and northern); Michigan (Marquette); Canada (Ottawa); Wisconsin; Nebraska; Colorado; Newfoundland.

95. *Bassareus mammifer* Newm. var. *sellatus* Suffr. (*Cryptocephalus sellatus* Suffr.). Dist. Columbia; New Jersey; "Middle and Western States"; Ohio; Indiana (Clarke, Hessville, Wolcott coll.); Michigan (Escanaba, Marquette, Detroit, North Muskegon, Holland); Wisconsin; Iowa; Canada; Colorado.

96. *Pachybrachys* sp. Michigan (Sault de Ste. Marie, Marquette).

97. *Gonioctena pallida* Linn. New Hampshire (summit Mt. Washington); Michigan (Marquette, Bachewanung); Minnesota; Wisconsin; Colorado; Hudson Bay region generally; Europe and Siberia.

98. *Phyllodecta vulgatissima* Linn. Virginia; New Jersey; New Hampshire (summit Mt. Washington); New York; Pennsylvania; Ohio; Illinois (central); Michigan (Detroit); Wisconsin; Iowa; Canada (Ottawa); Iceland; Siberia; China; Turkestan; Canaries. Perhaps also in Alaska.

Cistelidae.

99. *Hymenorus niger* Melsh. Florida; Texas; Dist. Columbia; New York; New Hampshire (Mt. Washington); Pennsylvania; Ohio; Canada (Ottawa); Michigan (Escanaba, Marquette, Detroit); Wisconsin; Colorado.

Melandryidae.

100. *Emmesa connectens* Newm. New Hampshire (summit Mt. Washington); Michigan (Marquette).

101. *Scotochroa basalis* Lec. Canada (Ottawa); Michigan (Escanaba, Marquette); Colorado.

Pythidae.

102. *Lecontia (Crymodes) disicollis* Lec. New Hampshire (summit Mt. Washington); Michigan (Marquette); Manitoba; Canada; (Ottawa); Idaho; Colorado; New Mexico.

103. *Boros unicolor* Say. Dist. Columbia; Michigan (Marquette); Canada (Ottawa).

104. *Rhinosimus viridiaeneus* Rand. (*nitens* Lec.). Dist. Columbia; Michigan (Detroit, Marquette).

Curculionidae.

105. *Pissodes dubius* Rand. New Hampshire (Mt. Washington); Canada; Michigan (Marquette); Wisconsin.

106. *Dorytomus brevicollis* Lec. Dist. Columbia; New Jersey; New York; New Hampshire (Mt. Washington); Ohio; Michigan (Marquette, Detroit); Colorado; New Mexico; Canada; Vancouver Island.

107. *Trichalophus alternatus* Say. Michigan (Michipicoton River); Wyoming (Laramie); Colorado.

108. *Apion* sp. Michigan (Marquette).

109. *Magdalis hispoides* Lec. Dist. Columbia; Michigan (Marquette, Port Huron); Colorado; British Columbia.

110. *Magdalis gentilis* Lec. Michigan (Marquette); Colorado; California.

111. *Magdalis armicollis* Say (*Magdalis alutacea* Lec. Bul. U. S. Geol. and Geogr. Surv. Terr., 4 p. 463, 1878). LeConte described *alutacea* from Isle Royale, Lake Superior (Mr. E. A. Schwarz) and Leavenworth Valley, above Georgetown, Colorado, specimens; the species is not given in Hubbard and Schwarz's list. It has since been found at various places in the mountains in Colorado; Ohio; Canada (Ottawa); New Hampshire (Mt. Washington); and a species doubtfully referred here occurs in New Mexico.

112. *Anthonomus corvulus* Lec. Dist. Columbia; Ohio; Illinois (River Forest, Bowmanville, Wolcott coll.); Michigan (Marquette, Detroit).

113. *Pseudanthonomus* (*Anthonomus*) *crataegi* Walsh. Florida; Dist. Columbia; Ohio; Illinois (central and northern); Michigan (Detroit, Marquette).

114. *Orchestes pallicornis* Say. "Nova Scotia to Texas, and to Puget Sound" (LeConte); Dist. Columbia; New Hampshire (Mt. Washington); Ohio; Michigan (Escanaba, Marquette, Detroit).

115. *Orchestes canus* Horn. Ohio; Type locality given thus: "Specimens are before me from Isle Royale and Escanaba, Michigan, and from San Juan, Colorado" Horn. Also known from Marquette, Michigan.

116. *Cnemogonus epilobii* Payk. Michigan (Marquette); British Columbia; Great Slave Lake, Northwest Territory; Colorado; northern and central Europe.

Scolytidae.

117. *Dendroctonus rufipennis* Kby. Alaska; "Vancouver to Anticosti, New Brunswick and southwest to Florida and New Mexico"; Western Pennsylvania; Michigan (Marquette).

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NOTES ON THE VEGETATION OF ISLE ROYALE, MICHIGAN.

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I. General Observations on the Plant Societies.

Situated in the northern part of Lake Superior, in sight of the Canada shore, and bisected by the parallel of 43° N., Isle Royale offers a most attractive field for summer work. That its flora is strikingly northern may be inferred from its proximity to the Canadian shore, as well as by the many species of northern plants included in the annotated list of plants.

The island, 45 miles long and containing about 210 square miles, has had almost no permanent population since the "copper days;" and only a few localities along the water's edge are frequented by summer visitors, thus leaving the island largely free from man's occupancy. With the exception of the buildings and mining improvements of the Wendigo Mining Company, at the head of Washington Harbor, little remains on the island to mark the vanished population, except the burnings and clearings, which are easily recognized by their characteristic floras.

Large parts of the island, however, have remained quite free from man's invasion. That the present natural conditions are not likely to remain long undisturbed, and that the past summer's observations and records were made none too soon, is shown by the fact that contemporaneous with the work of the Museum party there were at least three different parties of timber estimators working over large parts of the island looking toward the cutting off of the forests.

The general plan of the summer's work on the biota of the island was to select the most typical and representative parts as general stations, working these through sub-stations as carefully as time would allow, and comparing other similar localities with these.

The principal plant societies of Isle Royale may be considered under four heads, viz.: Bog societies, shore societies, forests, and burnings.

1. *Bog Societies.* It is doubtful if there could be found anywhere in an area of the same size a more interesting and more complete series of bogs than occurs on Isle Royale. On the geological map of the island, by Lane and Stockly, there are shown over 100 smaller bog areas, exclusive of the extensive bog region in the southwest part of the island, to the west of Siskowit Bay. Add to this the various stages of partly filled lakes, and there is shown almost every conceivable stage in the life history of bogs, from the open tarns, or lakes, to the climatic bog forest.

It is unnecessary to call attention to the very interesting manner in which the bog floras respond to the various stages of physical changes; such responses of vegetation in any physiographic series are too well known to need comment. For any student who desires to work out in detail these stages of successions as carefully and minutely as Cowles has done for the dunes of the Chicago region, Isle Royale presents all

that could be desired; and one important advantage here is that most of the bog areas are comparatively small, and all in a reasonably limited area, thus offering an unusual opportunity for their comparative study.

There is, on the other hand, one difficulty that should be mentioned in connection with any kind of field work on Isle Royale which takes one far back from the shore, and that is the difficulty of penetrating the dense tangles of the forest. The absence of roads, the limited number even of old blazed trails, the unusually dense underbrush, including a very rank growth of *Taxus minor* (Ground Hemlock) and numerous windfalls, together with the necessity of carrying by pack one's supplies—all render the penetration of many parts of the island a matter of such difficulty that it has been remarked by all who have attempted it.

In the limited time at our disposal during the summer it was impossible to visit all of the 100 or more bog areas on the island: our attention was therefore confined to a limited number of those which are typical of a certain stage of development, or to those having individual points of special interest.

Three general stages of the lake-bog series will be briefly touched upon, (1) the open lake *without* marginal vegetation, (2) the partly open lake *with* marginal vegetation of varying width, (3) the wholly carpeted bog area; the vegetative carpet in some cases being recent enough to give beneath the feet, in other cases old and solid enough to be more or less forested.

The first, or open stage, includes only a few of the largest lakes of Isle Royale, such as Lake Siskowit and Sargent Lake. Of these Lake Siskowit is by far the largest, being at least a mile and one-half broad in places. The principal reasons for the absence of vegetation in the lakes of the first class seems to be that their size and openings renders the sweep of the wind and the resulting wave action so vigorous that even annuals cannot get a foothold along their shores.

Wave action in a few places is clearly marked by a narrow but well-defined beach, as along the north shore of Lake Siskowit.

Another factor that has to be reckoned with in the larger lakes of the first class is the work of ice. Ice destroys shore vegetation in two ways, first—by pushing, due to expansion by freezing (and this total expansion in a lake as large as Lake Siskowit is considerable); second—the open expanse allows large ice floes to blow ashore during the spring break-up. The most interesting example of ice pushing noted was along the north shore of Lake Siskowit, where there is an irregular ridge, varying in height up to 15 feet and composed of bowlders and various fragmental materials. Along this ridge there were, in places, even over-turned trees of considerable size, pointing away from the lake, back 20 to 25 feet from the present shore. This ridge seems certainly to be the work of ice as in the case of the so-called "bowlder rim" lakes of the western United States, or the ice floe ridges at Put-in-Bay in Lake Erie.

In drawing a line between the lakes that will long continue to remain free from the encroachment of vegetation and those which are being gradually captured by vegetation, the size and openness seem to be the most important factors, affecting the vigor of wave action as well as the work of ice in one or both of the ways suggested.

In the smaller lakes, especially those nestled in depressions, the surrounding forests protect their surfaces from vigorous wind action so that there are practically no waves at all to check the encroachment of vegetation along the lake margins.

That the slope of the shore, in the case of protected lakes, has much to do with retarding or assisting the encroachments of plants is self evident. The Isle Royale lakes of the protected class show numerous examples where the plant zone is much farther advanced on the gently sloping side than on the opposite one with a more abrupt slope.

A typical example of a lake midway in the process of capture is Sumner Lake. This lake, which is roughly one-half mile long and one-third as wide, with its long axis nearly east and west, has already been captured at its east and west ends. Had its north and south borders been less steep the entire lake would doubtless have been covered ere this. This lake has an outlet into Conglomerate Bay, but at its west end it receives a small creek. The west end is covered by a bog carpet still so young and elastic as to render the crossing of it difficult. Along the more abrupt sides, and connecting the bog carpet at the ends, was a narrow, irregular zone of *Calla palustris* and *Iris versicolor*, with the *Menyanthes* (Buckbean) and *Comarum palustre* (Marsh cinquefoil) mixed in places. Parts of this zone, where the shore is less steep, were closely backed up by willows, *Cornus stolonifera*, and *Alnus incana*, thus giving to the marginal zone the aspect of a swamp rather than of a bog. Growing on the wet bog carpet at the ends were the *Sarracenia purpurea, Drosera rotundifolia, Drosera intermedia, Menyanthes trifoliata, Comarum palustre, Drosera linearis* (the latter two in wetter places generally than the former), *Oxycoccus oxycoccus, Habenaria psycodes, Habenaria dilatata, Pogonia ophioglossoides, Utricularia minor* (wetter parts), *Campanula aparinoides, Scutellaria galericula, Cicuta bulbifera, Triadenum virginicum, Parnassia palustris, Solidago neglecta,* etc.

A word in passing in regard to the "false bottom" of Sumner Lake, for in no place on the island was this better shown. In paddling around the open part of this lake on a raft it appeared in places that the water was only 6-10 feet deep. This was a matter of surprise since even a raft's length from the shore we could not touch bottom with our 15 foot pole. Further investigation showed a "false bottom" in various parts of this lake. This was composed of the fine, disintegrated remains of leaves and other light organic material. In places there were great breaks in this "false bottom," doubtless due to the escape of gases which has lifted this fine, ooze-like material from a greater depth; and through these breaks one could look down several feet through the brownish colored water. While this "false bottom" was so tenuous that a pole could be thrust through it almost as easily as through the clear water, it seemed to play an important part in the distribution of patches of *Castalia odorata* (White Pond Lily) so abundant on the surface of the lake, and also served to call attention to the manner in which this material assists in lake filling.

An area illustrating the final stage of bog covering was examined at the end of the cabin trail from our Siskowit Bay camp. In this sphagnum bog (V, 5), containing 80-100 acres, all has been covered

except an area of open water about 60 feet long and half as wide surrounded by an exceedingly wet, unstable margin.

A few years hence and even this will be covered. The main part of the bog was covered with sphagnum hummocks, upon which were growing *Ledum groenlandicum, Chamaedaphne calyculata* and *Andromeda polifolia* in dense patches. Young Tamaracks and Black Spruces were pushing out from the older parts of the margin, with Balsam Firs close behind.

Along the south margin of this bog, in the tension zone between the bog and the adjacent forest, there was being waged one of the most intense and most interesting struggles for plant supremacy that we have ever seen. Working up the gentle slope from the bog margin the sphagnum invasion (after the manner of a large snowdrift) was pushing out its lobate fingers, over the forest carpet of leaves; and during a single season by its rapid growth had surrounded such plants of the forest as *Aralia nudicaulis, Trientalis americana, Clintonia borealis, Lycopodium lucidulum*, all of which were completely helpless in the path of the sphagnum invasion. Even large, fallen trees were able to check its advance only temporarily, for instances were noted where entire fallen trunks were covered, only the upward projecting branches being out of reach of the Sphagnum. In a dry carpet of forest leaves the clean-cut forward margin of the sphagnum was so wet that water could be wrung from it at a distance of 15-20 feet from the original bog margin, thus showing how readily water is transferred through the sphagnum patches, even up a slope.

While the sphagnum invasion was eminently successful against all the *scattered* plants of the woods there was at least one species of moss (*Polytrichum commune*) growing in dense formations which was successful in holding the sphagnum in check. The moss colonies were so dense that the sphagnum could not penetrate them; on the other hand the moss was actually invading the moist sphagnum and growing over it.

Before leaving the semi-enclosed lake bogs a few questions suggest themselves regarding the trembling bog carpet adjacent to the water's edge. What is the thickness of this elastic, quaking water cover which is, at the same time, strong enough to enable one to walk out to within a single step (in some cases) of the water's edge? Also of what is it composed? In all the measurements taken it was found that this vegetative cover, within two to three feet of the water's edge, had a thickness varying from 22-24 inches. Back from this younger and more unstable margin the bog cover becomes thicker and firmer. In one bog, back about 100 yards from the water's edge, where the surface was firm and unyielding, the boring pole broke through into open water at a depth of 5 feet 6 inches. In another instance, at the west end of Sumner Lake, at a distance of over 100 yards back from the water's edge, I found the bog cover still so thin and trembling that I broke through in one place in attempting to walk across it, and anticipated that the same might happen in several other places. These and other instances all go to show that no definite statement can be made as to the exact distance from the water's edge at which the bog cover becomes thick enough to support one. This may vary with the depth of water underneath, as well as the distance from the original shore

It is to be regretted that more borings and measurements could not have been taken in the limited time at our disposal. A summer spent with suitable boring tools in making an extended series of borings over various parts of several of the Isle Royale bogs and bog-lake margins would doubtless bring to light some very interesting data.

Now as to what gives strength to the bog cover. Since the sphagnum is so predominant on bog areas, covering large parts of the surface, and often extending out almost to the water's edge, one is apt to think only of the sphagnum surface and fail to consider the important network below that gives such strength to the trembling bog carpet out almost to the very water's edge. It is scarcely necessary to add that the delicate sphagnum alone is not sufficient to make a *strong* bog cover. The weakness of the individual sphagnum plants to resist strain, the lack of interlacing parts, or of even "felting" properties are clearly shown in that one can reach down a foot or more into the loose, soft, sphagnum and pull out a handful of it without seriously disturbing the adjacent plants. Moreover, the sphagnum does not grow along the water's edge *in advance of* its supporting mat—at least we failed to find a single instance of this on Isle Royale—while in many cases it did not extend out to within several feet of the water edge of the supporting mat.

On pulling up large masses of the floating mat at the water's edge it was found to consist of a dense tangle, or network, of tough fibrous roots and rhizomes of sedges, *Menyanthes trifoliata* and *Comarum palustre,* all so tightly interlaced that it was very difficult to separate any part of the tangle from the rest. Such tough parts are in striking contrast to the delicate sphagnum, as is also the manner of growth; and furnish the platform on which the sphagnum works out toward the lake margin.

In the last, or wholly covered, division of bogs a wet and a drier stage may be recognized; the former may be characterized by the *Sarracenia purpurea, Menyanthes trifoliata, Comarum palustre,* and one or more species of *Drosera.* Sphagnum hummocks may occur in both of these covered stages, or the surface may be comparatively smooth. These hummocks, of varying size up to 4 feet in height, seem to be due in most cases to the sphagnum growing up around tree trunks, shrubs, or other objects. Instances were noted of where the rapidly growing sphagnum had so nearly covered the *Ledum groenlandicum* that only the ends of the upper branches were to be seen. It is possible, however, that some of the hummocks may be formed in other ways, e. g. one large hummock was noted that was inhabited by ants. This suggested that possibly the sphagnum had overgrown a large ant mound, although it is also possible that the ants may have inhabited the mound only after its formation in some other way.

The pioneer trees to appear in Isle Royale bogs are the *Larix laricina* (Tamarack), and *Picea mariana* (Black Spruce), which appear simultaneously, and seem equally well adapted to bog conditions. Owing to the advance of the bog cover from the margin toward the centre, one naturally expects to find the youngest trees farthest in, and this is strikingly well illustrated in many of the bogs.

By counting the rings of trees cut in the bogs, and comparing with the same species just outside, it was found that the growth of those in

the bogs was strikingly slower. The rings of the bog species were in many cases so close together as to render a hand lens desirable for counting them, while the annual rings of the same species in the adjacent forest were widely separated.

2. *Shore Vegetation.* The work done on shore forms was confined entirely to the south shore, including the group of small islands near the abandoned Light-house at Rock Harbor. The northern shore is steep and cliff-like, the southern shore gently sloping. While the northern shore is strikingly different from the southern, and might have brought to light many interesting things (especially in the way of lichen formations), it seemed best to confine the limited time at our disposal to work on the south shore.

Of the special shore forms, the crevice plants are both interesting and attractive. The crevices in most cases are due to fissuring, although some long, narrow grooves were made by the differential weathering of the softer vein rock. The bed-rock of the shore is often amygdaloidal, and many small depressions in this, due to the more rapid weathering, afford a foothold for the hardy plants of the rock shore. In their narrow rock crevices and confines, with little soil, and on dark-colored rock which in summer becomes highly heated, at all times exposed to the strong lake winds, and in winter often washed by the powerful storm waves of Lake Superior, their struggle for existence is certainly a most strenuous one. On the whole their size and appearance is strikingly alpine, as is also their coloring in many cases.

A partial list of the crevice plants is as follows: *Campanula rotundifolia, Potentilla tridentata, Potentilla littoralis, Saxifraga tricuspidata, Saxifraga aizoon, Saxifraga nivalis, Artemisia canadensis, Senecio balsamitae, Primula mistassinica, Solidago virgaurea* (?), *Sagina saginoides, Achillea millefolium, Aster ptarmacoides, Sisymbrium humile. Lobelia kalmii, Nabalus racemosa,* etc. The insectivorous *Pinguicula vulgaris* (Butterwort) occurs in rock pools and on wet rocks along the rocky shores.

The most common crevice shrubs were the *Juniperus nana, Juniperus procumbens, Arctostaphylos uva-ursi* (Bear-berry), *Shepherdia canadensis* (Shepherdia), *Opulaster opulifolius* (Ninebark). On the exposed rocks at Scovill Point and at the eastern end of the island, the *Empetrum nigrum* (Crowberry) was also found, forming a part of the heath mat. Of all these the *J. procumbens* is easily of the greatest importance in preparing the way for other larger forms of plants. Certainly no shrub of Isle Royale precedes it or has better claims for pioneer distinction. Its hardiness, prostrate manner of growth, and its thick, sheltering branches are all of great importance in making it an excellent pioneer.

A study of the small rock islands near the Rock Harbor light-house was very interesting not only on account of the striking differences in the individual flora of each, but also for a comparative study of the plant successions upon them. All stages of successions were noted from an unusually rich mesophytic flora, growing on a humus soil 3-10 inches in depth, down to islands almost bare except for a few crevice plants. In general all the islands showed a less development of the flora on the side exposed to the open lake than on the more protected land side: in some cases the vegetation of the two sides was strikingly different.

The advantages of crevices in enabling vegetation to get a start upon

bare islands was well illustrated in the case of one of the small islands of this group. Its smooth, sloping surface was bare except for a few small patches of crustaceous lichens and a single large procumbent juniper. The juniper was growing in a crevice along which it had reached for several feet in either direction, occasionally rooting along the crevice which held it more securely in place. The spaces between its dense sheltering branches were filled with a vigorous growth of moss which doubtless started on the wind-blown material that had lodged there. So solidly had the moss filled the spaces between the branches where it was growing that in breaking off a portion of the juniper everything was stripped off down to the bed-rock. As such a juniper patch spreads, and the humus made by the moss increases, other plants come to grow on the juniper patch, and an ever-increasing heath mat is formed. Other similar crevices may, in like manner, spread to join this, and in a comparatively short time the entire surface is carpeted with vegetation. On other small islands crevice trees and shrubs have contributed shade and partial protection from the wind, and the process has gone on even more rapidly. Had there been no crevices to enable these higher pioneer plants to secure a foothold the process of vegetative capture would have gone on infinitely slower. What the possible steps are in such a case may best be considered in connection with the rock shore-heath-forest series to be referred to presently.

To suggest the severe and varied conditions of the exposed rock shore the following is cited. On a bare, gently sloping (10°-12°) portion of the rock shore near Rock Harbor, there were, in an area approximately 40 feet square, over 100 fresh scars where the thin (1-6 to 1-8 inch) patches of rock had recently been broken off. These patches varied in size from 12 inches in diameter down: some were covered in part by lichens (principally Parmelias), others were entirely bare. The intense daily heating and expansion to which the immediate surface of the dark colored, exposed rocks is subjected, together with the rapid cooling and the resulting contraction at night, doubtless has much to do with weakening the immediate surface, and *starting* the chipping. The freezing of moisture in the rock surface may have been responsible for the final breaking away and lifting.

For a brief survey of the vegetation from the water's edge back through the heath zone to the forest at the top of the gently sloping rock shore area, V 2, (designated as "the heath zone and beach" of Siskowit Bay) will be selected as a typical locality, and supplemented by additional observations on similar places elsewhere along the southern shore. The portion of rock shore to be considered has a rather uniform slope of about 10° and a width of 200-250 feet from the water's edge back to the forest at its summit.

The first zone of no vegetation extends back about 20-25 feet from the water's edge, although the winter waves doubtless reach far beyond this. Back of this occur, in turn, the crustaceous and foliaceous lichen zones, which meet in a somewhat irregular tension zone that can, nevertheless, be distinguished by looking up or down the shore. The lichens of these zones are included in the annotated list, and will not be enumerated here.

Numerous crevice plants (as already listed under shore forms) make their appearance in the crustaceous and foliaceous lichen zones, also *Thuja occidentalis* and *Picea canadensis,* the former being the hardier

pioneer of the two. In parts of the upper, or third, lichen zone there are unusually dense and luxuriant formations of Cladonias, often 50-60 feet across. Scattered among the Cladonias were *Juniperus nana, J. procumbens, Arctostaphylos uva-ursi,* and *Vaccinium pennsylvanicum.* The upper, or back portion, of this zone will be designated as the Cladonia-heath zone, for it is here that the real shore heath begins. The back of the heath zone contains numerous young Balsam Firs and White Birches which have worked in irregularly from the adjacent forest.

A similar sloping rock shore near our Siskowit cabin camp (V, 4) showed some interesting later stages. The shore was here better protected from waves and wind by the flat neighboring wooded islands; and the forest development had gone on more rapidly, having extended irregularly from the higher shore down to the very water's edge suggesting the ultimate condition elsewhere along the less protected rock shore. There were still open places, suggesting the irregular manner in which the trees had pushed out to take possession of the lower shore; but the forest was here far better established (seemingly on account of the better protection) than elsewhere along the beach where exposed directly to the lake winds and waves.

As the trees increase in number, and afford better conditions of shade and moisture, vigorous mosses and wood plants begin to invade the Cladonia patches still occupying the more open places. A series of photographs was taken showing various stages of this invasion of under-growth wood plants, from a pure formation of Cladonias to a climax of a dense society of wood plants with not a vestige of Cladonias remaining. These later back shore formations were equally well shown along the heath-forest tension zone at Rock Harbor.

If carefully worked out the rock shore series, from the water's edge back to the neighboring forest, might be made to rival in interest the lake-bog-forest series, so deserving of more careful study on Isle Royale.

3. *Forests.* The forests of Isle Royale include about 21 species of trees, 13 of which are deciduous, the remainder evergreen conifers. The paucity of species has been more than offset by a generous distribution and abundance, for the island as a whole is heavily forested. The largest and dominant trees of the present forest are *Abies balsamea* (Balsam Fir), *Betula papyrifera* (White, or Canoe Birch), and *Picea canadensis* (White Spruce), with the exception of the western end of Greenstone ridge where *Acer saccharum* (Hard Maple), *Betula lutea* (Yellow Birch), and *Betula lenta* (Black, or Cherry Birch) are dominant.

Between the end of Washington Harbor and Lake Desor there are places where almost pure stands of Hard Maple and birches obtain. The scarcity of *Abies balsamea* here, which is so abundant over almost all other parts of the island, is an interesting matter of speculation. Young Balsam Firs were noted growing in the shade and shelter of the maple groves, and they appeared to be vigorous and thriving, yet scarcely a large fir could be found associated with the maples in this part of the Greenstone ridge. An examination of the soil here showed that it is only 4-6 inches deep. This, together with the laterally limited root system exhibited by the larger overturned firs, seemed to suggest that, after attaining a certain height and rigidity, they became sufficiently exposed to be overturned by the powerful winds that sweep that exposed part of the Greenstone ridge.

The forested bog areas are characterized by the dominance of Tamarack, Black Spruce and White Cedar. As a rule, where the Tamarack is more abundant the White Cedar is less abundant, and the opposite. Where the White Cedar is dominant (as it is in many bog areas, the largest trees being 2—3½ feet in diameter), the few Tamaracks present are large and appear as pioneer relicts. The White Cedar, moreover, does not appear with the Black Spruce and the Tamarack in the earliest, wetter stages; but seems to come in only when a drier condition has been reached.

It may also be added that none of these characteristic bog trees are here so closely confined to their bog habitats as to the south of here; but they have a much more general distribution. The Black Spruce, for example, one of the earliest pioneers of the bogs, occurs sparingly distributed in the original forests along with the White Cedar and Balsam Fir; and I have also noted it growing on dry exposed rocks where very little soil was present. The Tamaracks also get out of the bogs and occur sparingly distributed in the upland forests—sometimes in most unexpected places.

Of all the island conifers the *Abies balsamea* is easily the most common, and seems to be superseding the spruces and tamaracks. The young seedlings of it grow in dense shade, as well as in more open places. Seedlings of the Balsam Fir come up abundantly under the White Spruces in place of the seedlings of that species which do not seem to be able to endure the shade of the dense forest. It will doubtless form an important part of the *climatic* forest of the island.

The *Picea canadensis* is fairly common along the margins of forests, and in the more open parts—even in the deeper parts of the forest—when it has come in as a pioneer with firs and other conifers of the present generation; but the White Spruces do not seem likely to succeed themselves and become a considerable part of the dominant forest, on account of the inability of their seedlings to withstand deep shade.

4. *Burnings.* The burnings and old clearings are everywhere characterized by an abundance of *Populus tremuloides* and *Betula papyrifera*, while the undergrowth consists largely of *Diervilla diervilla*, *Aster macrophylla*, *Chamaenerion angustifolium*, *Rubus parviflorum*, *Cornus canadensis*, and in places an abundance of *Taxus minor*. Burnings of *different periods* were suggested by uniform stands of Quaking Aspens and White Birches which were of different heights.

The Pennsylvania Cherry (*Prunus pennsylvanicus*) occurs in burned areas and elsewhere where there is little soil, sometimes growing out of the crevices of exposed rocks where the conditions of growth were strikingly unfavorable. Perhaps no other tree on Isle Royale can withstand more xerophytic inland conditions, with the possible exception of the Jack Pine (*Pinus divaricata*) which was occasionally found associated with it on high exposed ledges. In one locality where the two were growing in close company—a high rocky ledge near Conglomerate Bay (III, 5)—there was an almost total absence of soil, due to its removal to lower altitudes by wind and rain; there was a striking range of 50°-70° F. in the daily temperature, and a complete exposure to the powerful Lake Superior winds which overturn so many trees when they had developed enough heart wood to become rigid and

resisting. There might be added to the unfavorable conditions of growth on such exposed ridges the work of Hares, for the Northern Varying Hare often resorts to the exposed heights—as in the case just noted—for its winter feeding ground, since there is probably less snow left there by the sweeping winter winds than at lesser elevations, and the Hares can get about more easily. The principal damage done to the trees by Hares consists of the cutting off of the young branches, and gnawing the bark, and this in some cases amounts to considerable.

Scattered individuals of White Pine (*Pinus strobus*) occur along the ridges and on the north side of Siskowit Lake, but it is nowhere abundant. Only a few Norway Pines (*Pinus resinosa*) were noted—these occurring principally on ridges and in exposed places, as on the ridge north of Sumner Lake (III, 5).

The Green, or MountainAlder (*Alnus alnobetula*) was widely distributed on higher ground, and can seemingly stand as much shade as any broad leaved tree on the island. The Speckled Alder (*Alnus incana*) was common near the water's edge and on low ground; and in places had worked back some distance from the water.

The *Sorbus americana*, found on many parts of the island, was in most cases solitary in its distribution and nowhere abundant. It appears to be most abundant along the water's edge.

The successions of the burnings and clearings due to the attempts of the early copper prospectors to clear the land, as well as the results of later forest fires, present an interesting problem; also the peculiar distribution of the Hard Maple and White Pine on the island. Students of fleshy fungi may also find a most fascinating field for later summer work at the west end of the island, especially along the forest road from the Washington Club grounds to Lake Desor. Never have we seen a more inviting field for mycologists; and in a region as yet untouched as to its fungi.

In conclusion, we beg to call attention to the fact that, owing to time limitations, no attempt was made to work out in detail any of the large and interesting problems that presented themselves; our object being rather to make a general reconnaisance of the plant life on as many different parts of the island as possible. It is to be regretted that time did not permit the party to investigate several habitats on the north side of the island in addition to the work done on the south side, for the physiographic conditions there are different from those on the south shore, and a comparison of the environmental conditions of the two localities would doubtless throw additional light upon the series of shore societies.

To give a more detailed account of the plants noted and collected on the island than could be attempted in this resumė of conditions the following annotated list is herewith presented.

The writer is indebted to Dr. C. A. Davis of the Michigan Biological Survey for the determination of the sedges and certain flowering plants; to Prof. Bruce Fink of Miami College, Oxford, Ohio, for the determination of the lichens; for the determination of the mosses to Prof. J. M. Holzinger of Winona Normal School, Winona, Minn., and Dr. J. Roll, Germany.

The nomenclature is that of Britton and Brown's Illustrated Flora of

the Northern States and Canada, 1898. The report of the expedition for 1904 followed the nomenclature of Britton's Manual of the Flora of Northern United States and Canada, 1901.

II. Annotated List of Plants.

Lichens.

By lichen zone No. 1 is meant to include the *crustaceous lichens;* these forming small patches on the rocks as in *Placodium elegans,* in which the thallus is principally imbedded in the rock so closely that the rock must be broken away to secure them. Zone No. 2 (Foliose zone) includes the flat thallus species which are attached by rhizoids, as *Parmelia.* These can be scraped or pulled off. Zone No. 3 (Fruiticose zone) includes the upright lichens like *Cladonia.*

1. *Ramalina calicaris farinacea* (C) Fr. Vertical rock cliffs at water's elge. Principal branching lichen on vertical cliffs. Common Sta. I, Sub. 1.

2. *Cetraria lacunosa* Ach. On nearly bare surface of rocks Siskowit Bay, (V, 2). Occasional.

3. *Evernia prunastris* (C) Arch. A light green, branching form growing in Cladonia zone (I, 1).

4. *Usnea barbata cerotina* (Ach.) Schaer. Hanging from trees along Siskowit cabin trail (V, 4), also on trees at Rock Harbor (I, 3). Common.

5. *Usnea longissima* Ach. A pendulous form 12-15 inches or more in length. Occurs on conifers. Less common than preceding species.

6. *Parmelia perlata* (Jacq.) Ach. Top of cliff at Rock Harbor (I, 2). Not widely distributed.

7. *Parmelia saxitalis sulcata* Tayl. A gray foliose form growing on very thin black humus on sloping tops of cliffs. Noted to be abundant top of rock cliff at Rock Harbor (I, 1).

8. *Parmelia caperata* (C) Ach. On rocks of foliose lichen zone at Rock Harbor, I, 1; V, 2.

9. *Parmelia conspersa* Ehr. One of the most common lichens on the island, and the principal form in the second (foliose) lichen zone of the sloping rock shore. Also fairly abundant on rock surfaces back from the shore. I, 1; V, 2; V, 3; I, 2.

10. *Physcia pulverulenta* (Scrieb.) Nyl. Natural openings on bed rock, growing on very thin hard humus. V, 3.

11. *Gyrophora hyperborea* Ach. On almost bare rock in the foliose lichen zone (No. 2). Scarce. V, 2.

12. *Gyrophora (Umbilicaria) vellea* (C) Ach. Occurs in patches on vertical rock faces. I, 1. Fairly common.

13. *Sticta pulmonaria* (C) Schaer. Common along Siskowit cabin trail, on trunks of fallen trees. Fairly common in similar places elsewhere in forest. V, 4; II.

14. *Peltidea (Peltigera) aphthosa* (L) Ach. In forest along cabin trail to bog at Siskowit Bay. Fairly abundant (V, 4).

15. *Peltigera canina* (C) Hoffm. On moist moss patches in woods, and in shady places. Common. V, 4.

16. *Placodium elegans* (Link) DC. On exposed rock surfaces along

shore. Very abundant. Also on conglomerate. Gives a striking dark orange color to the cliffs along the main shore and on surfaces of small rock reefs and islands. I, 1; V, 2. The most striking lichen of the crustaceous lichen zone.

17. *Lecanora rubina* (Vill.) Ach. In foliose lichen zone. Not common. V, 2.

18. *Lecanora muralis* Schrieb. In low rocky reefs scarcely above the action of summer waves. I, 1. Not abundant.

19. *Lecanora frustulosa* (Dichs.) Ach. Rocky shores and cliff faces, also in patches among parmelias. I, 1; V, 2.

20. *Lecanora subfusca allophana* Ach. Rocky shores and exposed rocks. Fairly common, I, 1; V, 2.

21. *Lecanora cinerea gibbosa* (Ach.) Nyl. Back 20-25 feet from water's edge in second or foliose lichen zone, in lower edge of same. V, 2.

22. *Stereocaulon coralloides* Fr. In foliose lichen zone. V, 2.

23. *Stereocaulon paschale* (C) Ach. Rocky openings near Siskowit cabin. V, 3. Not abundant.

24. *Cladonia rangiferina* (C) Web. Very common in cladonia zone on all parts of shore where cladonias occur. Probably most abundant of all cladonias noted.

25. *Cladonia sylvatica* (C) Hoffm. Very common in cladonia zones. Lighter and smaller than preceding. Common in V, 2; I, 1.

26. *Cladonia alpestris* (L). One of the principal forms in cladonia zone in the shore-heath series. Common. I, 1; V, 2.

27. *Cladonia coccifera* (C) Willd. Thin earth on exposed rocks. Fairly common. II, 3; V, 7 (in burned area).

28. *Cladonia deformis* (C) Hoffm. On partly decayed bark and wood of fallen trees. Not common. V, 4.

29. *Cladonia cristatella* Tuck. On old wood. V, 4.

30. *Cladonia crispata* (Ach.) Fib. Forest trail Siskowit. Also found growing into moss patches in woods. V, 4.

31. *Cladonia amoaurocraea* (Flk.) Schaer. A cladonia in heath-cladonia zone at Rock Harbor, I, 1. Patches of this are being invaded by moss.

32. *Cladonia furcata pinnata* Flk. Growing along cabin trail on debris, and on fallen conifers. V, 4. Not abundant.

33. *Cladonia turgida* (Ehrh.) Hoffm. Growing on thin humus accumulation on open rocky places, V, 4. Also along portage to Siskowit Lake (V, 9).

34. *Cladonia gracilis dilatata* (Hoffm.) Wain. On thin humus covering of bed rock. Natural forest "openings." V, 4, 3.

35. *Cladonia verticillata* Hoffm. Woods and rock clearing at Siskowit Bay station, V, 4, 5.

36. *Cladonia pyxidata* (C) Hoffm. Rock shore in foliose and fruiticose lichen zones. V, 2. Not abundant.

37. *Cladonia fimbriata simplex* (Weis) Wainio. On decaying bark of fallen trees in forest. Forest trail from Washington Harbor to Lake Desor.

38. *Cladonia fimbriata coniocraea* (Flk.) Wainio. Bark of fallen trees in forest along Siskowit cabin trail. V, 4. Not abundant.

39. *Lecidea lactea* (Flk.). In rather small patches on exposed sloping and vertical rocky cliffs. Common on the water side of crustaceous or lower lichen zone. A white lichen with black dots. I, 1; V, 2.

40. *Endocarpon miniatum* (C) Ach. Rock surfaces with little soil, along Siskowit cabin trail, V, 4. Also in lower crustaceous lichen zone. V, 2; I, 1. Not abundant.

41. *Endocarpon miniatum saauaticum*. In lower crustaceous lichen zone within reach of winter waves. Not abundant. I, 1; V, 2.

42. *Ichmodophila aeruginosa*. On decaying bark of fallen trees along Siskowit cabin trail. Scarce. V, 4.

43. *Rhizocarpon* (*Buellia*) *geographicum* (C) DC. A small green lichen occurring in small patches on rocky shores in crustaceous lichen zone, often near the water. Can only be removed by chipping away the rock on which it grows. Fairly common. I, 2; V, 1.

Mosses.

44. *Sphagnum teres* Aug., var. *tenellum* Rl., *bicolor*.
45. *Sphagnum robustum* Rl., var. *gracile* Rl., *palleus*.
46. *Sphagnum girgensohnii* Russ., var. *molle* Crev., *palleus*.
47. *Sphagnum platyphyllum* Sull., var. *subsimplex* Cdbg., *glaucum*.

The above sphagna were abundant in all the bog areas of the island, and were of occasional occurrence on the low ground along creeks and elsewhere on low wet ground. I, 4; I, 6; II, 2; II, 5; III, 5; IV, 10; V, 5; V, 8; V, 11.

48. *Georgia pellucida* (*Tetraphis pellucida*). Woods along Siskowit cabin trail. V, 4.

49. *Polytrichum commune* C. A most vigorous moss growing in dense colonies; in places along the forest-bog tension zone successfully invading the sphagnum masses. The only plant of the woods that could hold its own against the invasion of the Sphagnum into the forest. Confined to moist or wet places. V, 4.

50. *Polytrichum strictum* Banks. Rather bare exposed places along Greenstone Ridge, also "natural openings" along the Siskowit cabin trail. V, 2; V, 4.

51. *Dicranum schreberi*. Near sphagnum bog at end of cabin trail. V, 5.

52. *Dicranum fuscescens* Turn. Occurs in small heads or clumps on dead wood. In woods. V, 4.

53. *Dicranum longifolium* Hedw. Woods along Siskowit cabin trail. V, 4.

54. *Dicranum scoparium* (C) Hedw. Woods along Siskowit cabin trail. V, 4.

55. *Dicranum undulatum* Voit. Woods along Siskowit cabin trail. V, 4.

56. *Grimmia unicolor* Hook. Confined entirely to small crevices and cavities in the bed rock of the gently sloping shore. It occurs nearer to the water's edge than any other form of vegetation observed on the island. No other mosses approach it in nearness to the water's edge, and it surpasses even the hardiest lichens of the crustaceous zone in this respect. Very hardy, and at times highly xerophytic. I, 1; V, 2. It is of a very dark greenish brown color.

57. *Leucobryum glaucum* (L) Schimp. Grows in heads of varying size, principally in woods. I, 3; V, 4.

58. *Tortella tortuosa* (L) Limpr. Rock ridges, and other rocky places. Grows in dense rounded tufts. II, 3.

59. *Ulota americana* (Beauv.) Lindb. Growing on gently sloping rock shore, sometimes covering crustaceous and foliose lichen patches. I, 1; V, 2.

60. *Bartramia pomiformis* (L) Hedw. Shady, moist niches and crevices in rock cliffs. A beautiful moss having the appearance of green wool. I, 1; V, 4.

61. *Bryum palleus* Swartz. On dead wood, and on thinly covered rock surfaces in woods, V, 4.

62. *Aulocomium palustre* (L) Schwaegr. Near bog at end of cabin trail Siskowit Bay. V, 5.

63. *Mnium punctatum* Hedw. Moist woods along Benson Brook; also in moist places along Siskowit cabin trail through woods. II, 1; V, 4.

64. *Leskea nervosa* (Schwaeg.). Myr. Closely associated with *Ulota americana* on the sloping rock shore where it sometimes covers patches of crustaceous and foliose lichens. I, 1; V, 2.

65. *Thuidium abietinum* (L) B. & S. Growing on fine material that has accumulated among the close branches of the low Procumbent Juniper. It was noted on one of the small rock islands in Rock Harbor which had little if any vegetation besides the crevices plants. It here plays an important part in the early formation of a humus soil by solidly filling in the spaces between the Juniper branches. I, 1.

66. *Hypnum crista-castrensis* L. On decayed wood in cool moist woods near peat bog. V, 4, 5.

67. *Hypnum schreberi* Willd. Rich, moist woods along forest road Washington Harbor; also noted growing in Cladonia patches in woods along Siskowit cabin trail. It seems to be replacing and succeeding the Cladonias in places. V, 4; I, 3.

68. *Hypnum scorpoides* L. Bog margin of Forbes Lake. II, 5.

69. *Hypnum vernicosum* Lindb. Bog beyond Malone's fishing camp. Back from V, 2.

70. *Hypnum polare* Lindb. Protected rock crevices, Rock Harbor. I, 1.

71. *Hypnum fluitans* L. Rock pools Scovill Point. IV, 1.

72. *Hypnum stramineum* Dicks. Bog beyond Malone's fishing camp. Back from V, 2.

73. *Hypnum aduncum* Sch. Bog at end of Siskowit Bay cabin trail. V, 5.

74. *Hypnum aduncum intermedium* Sch. Growing in water in margin of a brook emptying into Forbes Lake, II, 5.

75. *Hypnum uncinatum* Hedw. *formaplumosa* Sch. Moist woods along trail to Monument Rock. IV, 4.

76. *Hylocomium triquetum* (L) B. & S. Woods along Siskowit cabin trail. V, 4. Fairly common.

77. *Hylocomium splendens*. Woods along forest road from Washington Harbor to Lake Desor, III, '04.

78. *Distichium capillaceum*. From a partly protected vertical rock crevice 6-8 feet above water, Rock Harbor. I, 1.

79. *Neckera oligocarpa* B. & S. Forest road, Washington Harbor: woods.

80. *Dickelyma uncinatum* Mitl. (?) Growing in a pool on small island at upper end of Rock Harbor. Unusually large. III, 1.

81. *Palndella squarrosa* (L) Brid. Bog margin of Forbes Lake. II, 5.

Pteridophytes.

Ophioglossaceae—Adder's Tongue Family.

82. *Botrychium lunaria* (L) Sw. Moonwort. Rare. Partially shaded rocky ground near Rock Harbor light-house, I, 1.

83. *Botrychium virginicum* (L) Sw. Virginia Grape Fern. Sparingly distributed in rich woods. I, 3; III, 4; V, 4.

Osmundaceae.

84. *Osmunda regalis* L. Royal Fern. One locality. Rich low ground near small creek emptying into Forbes Lake, II, 5.

85. *Osmunda cinnamomea* L. Cinnamon Fern. Moist thickets and low ground. II, 5.

86. *Osmunda claytoniana* L. Interrupted Fern. Mesophytic woods. Not common.

Polypodiaceae—Fern Family.

87. *Onoclea sensibilis* L. Sensitive Fern. Fairly abundant.

88. *Onoclea struthiopteris* (L) Hoffm. Ostrich fern. Few localities: not abundant.

89. *Woodsia ilvensis* (L) R. Br. Rusty Woodsia. Several small, dense patches on rock surfaces, and along rock crevices. Island upper end of Rock Harbor and I, 1; V, 2.

90. *Cystopteris bulbifera* (L) Bernh. Bulblet Cystopteris. Thinly scattered on moist, shaded cliff faces. Cliff near Rock Harbor lighthouse.

91. *Cystopteris fragilis* (C) Bernh. Brittle Fern. Shaded, moist places. Not abundant.

92. *Dryopteris thelypteris* (L) A. Gray. Marsh Fern. Wet margins of bogs, and other low, wet places. Common in such places. II, 5; III, 5.

93. *Dryopteris fragrans* (L) Schott. Fragrant Shield Fern. Common in patches on cliffs and rocks along shore, I, 1.

94. *Dryopteris filix-mas* (L) Schott. Male Fern. Fairly abundant in rich, moist woods. Especially abundant near Benson Brook. II, 1.

95. *Dryopteris spinulosa* (Retz.) Kuntze. Spinulose Fern. Rich, moist woods. Fairly common. Unusually large and vigorous on Malone's Island in Siskowit Bay. III, 4; V, 4.

96. *Phegopteris phegopteris* (L) Underw. Long Beech Fern. Moist woods (IV, 4). Less common than *P. dryopteris.*

97. *Phegopteris dryopteris* (L) Fee. Oak Fern. Rich, moist woods. Fairly common. IV, 4; III, 4.

98. *Asplenium trichomanes* L. Maiden-hair Spleenwort. On thinly soil-covered rocks. Rare. Rock cliff along Siskowit cabin trail. V, 4.

99. *Adiantum pedatum* L. Maiden-hair Fern. Sparingly distri buted in the mesophytic forest. III, 4, and at Washington Club (forest).

100. *Pteris aquilina* L. Brake. Abundant in open, drier places, especially in burned areas.

101. *Cryptogramma acrostichoides* R. Br. American Rock Brake. In dense patches on exposed bed-rock where thinly soil-covered. Upper end of Rock Harbor and I, 1.

102. *Polypodium vulgare* L. Common Polypody. Tops and exposed edges of cliffs. Common. I, 1.

Equisetaceae—Horsetail Family.

103. *Equisetum arvense* L. Between forest and bog margin, Forbes Lake, II, 5.

104. *Equisetum sylvaticum* L. Wood Horse-tail. Moist woods. II, 1. Noted in one locality only.

105. *Equisetum palustre* L. Marsh Horse-tail. Wet, back-margin of bog.

106. *Equisetum fluviatile* L. Swamp Horse-tail. In water upper end of Rock Harbor. III, 3.

107. *Equisetum scirpoides* Michx. Depression in Arbor-vitae swamp along Siskowit Lake portage, (V, 9).

Lycopodiaceae—Club-Moss Family.

108. *Lycopodium selago* L. Fir Club Moss. Rare. Exposed rocks at Scovill Point, IV, 1.

109. *Lycopodium lucidulum* Michx. Shining Club Moss. Edge of rock pools Scovill Point, IV, 1, and in moist woods, III, 4.

110. *Lycopodium inundatum* L. Bog Club Moss. Wet bog margin, Sumner Lake. III, 5.

111. *Lycopodium obscurum* L. Ground Pine. Sparingly distributed in moist woods. I, 3.

112. *Lycopodium clavatum* L. Running Pine. Common in dry to moist woods. III, 4; V, 4; I, 3.

113. *Lycopodium complanatum* L. Fairly common in woods and shady places. V, 4; III, 4.

114. *Lycopodium annotinum* L. Stiff Club Moss. Cool, dry woods. V, 4.

Selaginellaceae—Selaginella Family.

115. *Selaginella rupestris* (L) Spring. On thinly soil-covered rocks along Siskowit Lake portage (V, 9). Sparingly distributed.

Isoetaceae—Quillwort Family.

116. *Isoetes* sp? In shallow water at upper end of Rock Harbor, III, 3.

Spermatophytes. (Seed Plants).

Naiadaceae—Pondweed Family.

117. *Potamogeton natans* L. Fairly common on margin of Sumner Lake. III, 5.

118. *Potamogeton perfoliatus* L. Clasping leaved Pond-weed. Margin of Sumner Lake.
119. *Potamogeton heterophyllus*. Schreb. Washington Creek.
120. *Potamogeton hillii* (?) Hill's Potamogeton. Margin of Sumner Lake.
121. *Potamogeton pectinatus* L. Margin of Sumner Lake.
122. *Naias flexilis* Willd. Slender Naias. Shallow water at head of Rock Harbor.

Scheuchzeriaceae—Arrow-Grass Family.

123. *Triglochin maritima* L. Bog margin of Sumner Lake. Not abundant. III, 5.

Vallisneriaceae—Tape-Grass Family.

124. *Vallisneria spiralis* L. Tape-Grass, Eel-Grass. Shallow water at head of Rock Harbor.

Graminae—Grass Family.

125. *Panicum xanthophysum* A. Gray. Dry rocky ridges, and rocks with little soil.
126. *Agrostis hyemalis* (Walt.) B. S. P. Rather dry ground.
127. *Calamagrostis canadensis* (Michx.) Beauv. Rock pool margins, Scovill Point, IV, 1. Creek margin upper end of Rock Harbor, III, 3. Wet places generally.
128. *Trisetum subspicatum* (L) Beauv. Common in rock crevices and dry places. Rock shore where little soil is present, where it occurs as the pioneer grass. I, 1; V, 2.
129. *Phragmites phragmites* (L) Karst. Washington Creek.
130. *Poa pratensis* L. A dry ground form. Island in Rock Harbor, III, 1.
131. *Panicularia canadensis* (Michx.) Kuntze. Upper end of bog at end of Siskowit cabin trail. V, 5.
132. *Panicularia elongata* (Torr.) Kuntze. Margin of Siskowit cabin trail bog. V, 5.
133. *Fescuta ovina* L. Rock crevices and on thinly soil-covered rocks. I, 2; V, 2.

Cyperaceae—Sedge Family.

134. *Eleocharis palustris* (L) R. & S. In shallow water at upper end of Siskowit cabin trail. V, 5.
135. *Eleocharis palustris glaucescens* (Willd.) A. Gray. (?) Wet part of island in Tobin Harbor.
136. *Scirpus caespitosus* L. Margin of Forbes Lake, II, 5. Rock pools, Scovill Point. IV, 1.
137. *Scirpus cyperinus* (L) Kunth. Low ground along "Island mine" road, head of Siskowit Bay.
138 *Eriophorum alpinum* L. Alpine Cotton-Grass. Most common "cotton-grass" on the island. Common in all the bogs. II, 2; III, 5.
139. *Eriophorum vaginatum* L. Sheathed Cotton-Grass. Sphagnum bogs. V, 11; III, 4; V, 5.

140. *Eriophorum gracile* L. Bog margin of Sumner Lake, II, 5.

141. *Rynchospora alba* (L) Vahl. White Beaked Rush. Common in wet bog margins. V, 11; II, 5.

142. *Carex pauciflora* Lightf. Few-flowered Sedge. Margin of Siskowit cabin trail bog. V, 5.

143. *Carex folliculata* L. Long Sedge. Associated with preceding species.

144. *Carex monile* Tuckerm. Necklace Sedge. Wet creek margin of bog near Malone's fishing camp, (V, 11).

145. *Carex tuckermani* Dewey. Along Washington Creek.

146. *Carex retrorsa Schwein.* Retrorse Sedge. Along Washington Creek.

147. *Carex riparia* Curtis. River-bank Sedge. Creek margin head of Rock Harbor, III, 3.

148. *Carex filiformis* L. Slender Sedge. Common in bog margins. II, 5; III, 5.

149. *Carex stricta* Lam. Tussock Sedge. Bog margins. V. 11; II, 5.

150. *Carex aquatilis* Wahl. Water Sedge. Bog margins. V, 11; III, 5.

151. *Carex limosa* L. Mud Sedge. Rock pools, Scovill Point, IV, I. Siskowit cabin trail bog. V, 5.

152. *Carex crinita* Lam. Along road to "Island Mine" head of Siskowit Bay.

153. *Carex arctata* Boott. Drooping Wood Sedge. Dry woods, Washington Harbor.

154. *Carex viridula* Michx. Edge of rock pools, and on moister parts of rock beach. I, 1; V, 1, 2.

155. *Carex chordorhiza* L. Creeping Sedge. Bog margins. V, 11; III, 5; II. 5.

156. *Carex tenella* Schk. Soft-leaved Sedge. Arbor-vitae depression, Siskowit Lake portage, (V, 9).

157. *Carex sterilis* Willd. Rock pools, Scovill Point, IV, 1, and Siskowit cabin trail bog. V, 4.

158. *Carex brunnescens* (Pers.) Poir. Rock pools, Scovill Point. IV, 1.

159. *Carex trisperma* Dewey. Three-fruited Sedge. Bog margins. II, 5; III, 5.

160. *Carex scoparia* Schk. Pointed Broom Sedge. Washington Club Grounds. I, '04.

161. *Carex festucacea* Willd. Fescue Sedge. Dry rocky places; rock ridges. II, 3; V, 3.

NOTE.—For more convenient reference the principal trees of the island will be grouped together instead of being placed under their respective orders and genera.

Pinaceae—Pine Family.

162. *Pinus strobus* L. White Pine. Large, isolated individuals occur along the Greenstone Ridge, and on other ridges; but is nowhere abundant. It is confined almost entirely to higher ground, and

to open, sunny places. Large, charred trunks 3-4 feet in diameter are still fairly abundant along the Greenstone and other ridges. Very few young trees of this species were noted; and there are no indications, at present, to suggest that it will again become abundant on the island. I, 3; II, 3; III, '04; VII, '04.

163. *Pinus resinosa* Ait. Red, or Norway Pine. Not abundant; noted in two localities only. Occurs on high, exposed ground. III, 4.

164. *Pinus divaricata* (Ait.) Sudw. Labrador, or Gray Pine. Fairly common on exposed, dry rock ridges, and on a few of the rock islands. Several in heath-forest tension zone near Rock Harbor light-house Able to withstand highly xerophytic conditions.

165. *Larix laricina* (DuRoi) Koch. Tamarack, or American Larch. Principally in recently filled bogs or working in along margins of partly filled ones. The tamaracks and Black Spruces are the pioneer trees of the bogs. In the older bogs the few large tamaracks present are relicts, and few young ones appear to be coming on. Scattered individuals occur throughout the upland forests but are nowhere abundant outside the bogs. Largest individuals noted (V, 8) were over 3 feet in diameter. I, 4; I, 6; II, 2; II, 4; II, 5; III, 5; IV, 4; IV, 8; V, 5; V, 7; V, 8; V, 11; V, '04.

166. *Abies balsamea* (L) Mill. Balsam Fir. The most characteristic and abundant evergreen of the upland forest. Abundant on all parts of the island except the Greenstone Ridge, and in the more recently filled bogs. Along the forest road from Washington Club to Lake Desor the absence of the larger firs was probably due to the shallowness of soil, exposure to the powerful winter gales (as soon as they overtop the maples and other trees among which they start to grow), and the reduced root system in proportion to the size of the tree. It reproduces readily in dense shade as well as more open places, and is not only succeeding itself but other forest trees, as the White Spruce. It will certainly occupy a large and important place in the climatic forest. Up to 2 feet in diameter. I, 3; I, 4; III, 4; IV, 4; IV, 8; IV, 9; V, 4; V, 7; III, '04.

167. *Picea canadensis* (Mill.) B. S. P. White Spruce. Older trees are fairly common where they have come in with *Abies* as pioneers. It does not appear to be succeeding itself except along the edge of clearings and in more open parts of the forest. Since the Fir seedlings are common under the older trees instead of those from the present spruces it appears that the White Spruce will be replaced by the Fir in the climatic forest, the Fir seedlings being able to endure much deeper shade. I, 2; I, 3; III, 1.

168. *Picea mariana* (Mill.) B. S. P. (Possibly *Picea brevifolia* Peck). Black Spruce. Confined principally to sphagnum bogs where it comes in with the tamarack as a pioneer. The largest trees noted were 2½ feet in diameter. Also sparingly distributed outside of bogs. In a few instances it was found growing on the exposed tops of cliffs (as at Rock Harbor) where there is only a thin covering of soil. I, 6.

169. *Thuya occidentalis* L. White Cedar or Arbor-vitae. Occurs in all bog areas except those most recently carpeted over. It does not appear to come in as a pioneer but follows closely *Picea mariana* and *Larix laricina*. Largest specimens in old bog areas, V, 8, were 40 inches

in diameter. Occasional in upland forest, in fact, fairly abundant in places; also one of the trees to occur in crevices on the small rock islands and along the rock shore, in which cases they have a decidedly stunted appearance, and are often broader than high. I, 4; I, 6; II, 2; IV, 4; IV, 8; V, 6; V, 7; V, 8; V, 11; II, '04; V, '04.

170. *Juniperus nana* Willd. Low evergreen shrub common on the back heath zone and along the rock shore. It appears to follow rather than to precede *Juniperus* (*procumbens*) *sabina* with which it is so commonly associated. A common form on the rock islands and in the rock shore crevices. Also in the natural rock openings back from the shore. I, 1; I, 2; I, 5; III, 1.

171. *Juniperus* (*procumbens*) *sabina* L. Procumbent Juniper. A very important pioneer on the rock islands and on the sloping rock shore, starting as a crevice plant and sending out its dense prostrate branches 6-10 feet. It offers a favorable place for wind blown material which there accumulates, and this is of great importance for the pioneer mosses which contribute so largely to the first humus soil. Some most interesting examples of these pioneer stages were noted on one of the low, nearly bare rock islands near the Rock Harbor lighthouse, I, 1, and at V, 2, it was very abundant.

Taxaceae—Yew Family.

172. *Taxus canadensis* Marsh. Ground Hemlock, American Yew. Everywhere abundant in the upland forests of the island. On account of its low, spreading growth it forms one of the greatest impediments in penetrating the island forests. The rankest growth was noted in the lower forest region around Washington Harbor, where it attains a height of four to five feet. I, 6; IV, 4; IV, 8; IV, 9; V, 4; V, 5; V, 7; V, '04.

Salicaceae—Willow Family.

173. *Populus grandidentata* Michx. Large-toothed Aspen. Principally along the Greenstone Ridge; not at all common as compared with *P. tremuloides*.

174. *Populus tremuloides* Michx. American Aspen. Very common on almost all parts of the islands where burnings and clearings have occurred. This and the *Betula papyrifera* are the pioneer deciduous trees in burned and cleared areas, where the two seem about equally abundant, colonies of both being intimately associated. Younger and older stands of this as noted along the Greenstone Ridge near Rock Harbor, suggest the younger and older burnings by the copper prospectors. I, 1; I, 2; I, 3; I, 5; I, 6; I, 7; II, 1; II, 3; III, 4; IV, 5; IV, 9; V, 8; V, 9; V, 3; V, 4; V, 5; V, 7; I, '04; III, '04.

75. *Populus balsamifera* L. Balsam Poplar. One locality only; head of Siskowit Bay.

Betulaceae—Birch Family.

176. *Corylus rostrata* Ait. Beaked Hazel. Rocky slopes and summits of ridges. In thickets along the Greenstone.

177. *Betula papyrifera* Marsh. Paper, or Canoe Birch. Common

everywhere in forested portions as well as burnings and clearings. This and the Balsam Fir seem to be the climax trees of the upland forest. I, 2; I, 3; I, 7; II, 1; III, 4; IV, 8; IV, 9; V, 3; V, 4; V, 7; I, '04; III, '04.

178. *Betula lutea* Michx. F. Yellow Birch. Noted only along the forest road from Washington Harbor to Lake Desor, where it was very common along the Greenstone Ridge. Specimens 36 inches in diameter were noted. III, '04.

179. *Betula lenta* L. Black or Cherry Birch. Associated with *B. lutea* as mentioned above. Also attaining great size. III, '04.

180. *Alnus alnobetula* (Ehrh.) Koch. Green, or Mountain Alder. Fairly common in upland forest at Rock Harbor. Common shrub along with birches and aspens.

181. *Alnus incana* (L) Willd. Speckled Alder. Low ground, borders of streams and margins of lakes. Along water's edge at Rock Harbor, and sparingly associated with *Alnus alnobetula* in the forest back from water.

Note.—Thru an over-sight the 3 species of *Salix* observed were omitted in preparing this list for the press.

Fagaceae—Beech Family.

182. *Quercus rubra* L. Red Oak. A single specimen was noted along the forest road between Washington Club and Lake Desor, (III, '04). The *only oak noted on the island.*

Pomaceae—Apple Family.

183. *Sorbus americana* Marsh. American Mountain Ash. Fairly common along the forested margins of the principal inlets, as Rock Harbor, and sparingly distributed through the inland forest. Always more or less isolated, never in colonies.

184. *Aronia nigra* (Willd.) Britton. A single specimen noted on north side of Rock Harbor.

185. *Amelanchier alnifolia* Nutt. Northwestern June-berry. A shrub 6 feet or less in height. Rock openings also rock ridge near Conglomerate Bay (I, 5).

186. *Amelanchier oligocarpa* (Michx.) Roen. Oblong-fruited June-berry. A shrub about the size of preceding, but occurring on lower ground.

Drupaceae—Plum Family.

187. *Prunus pennsylvanica* L. Wild Red Cherry, Pennsylvania Cherry. Characteristic of xerophytic places as rock openings, talus slopes, and burnings; and able to thrive in exposed rocky positions where subject to great temperature extremes, and where there is very little soil. I, 5.

188. *Prunus virginiana* L. Choke Cherry. Woods: not common.

Aceraceae—Maple Family.

189. *Acer saccharum* Marsh. Sugar or Hard Maple. One part of the island, on the summit of the Greenstone Ridge along the forest

road from Washington Harbor to Lake Desor, it is very abundant. Reported to occur sparingly along other parts of the Greenstone, but seems to be confined entirely to the higher parts of the summit ridge. Along this "forest road" it forms almost pure stands, in other places there is *B. lenta* and *B. lutea* mixed with it. Some of the trees are 2-3 feet in diameter. (III, '04.)

190. *Acer spicatum* Lam. Mountain Maple. Generally distributed in the forest, but nowhere very abundant. Largest trees over 30 feet high. One of the lower growth forms to invade the forest roads. Often in rocky places. V, 7; III, '04.

191. *Acer pennsylvanicum*. Striped Maple, Moosewood. Rare on island.

Cornaceae—Dogwood Family.

192. *Cornus stolonifera* Michx. Common in low ground and back margins of bogs. A prominent member of the shrub zone surrounding small lakes.

193. *Cornus circinata* L'Her. Round-leaved Cornel. Sparingly distributed in rich woods.

Araceae—Arum Family.

194. *Calla palustris* L. Water Arum. Lake margins, especially abundant at Sumner Lake. III, 5.

195. *Spathyema foetida* (L) Raf. Skunk Cabbage. Common in low grounds in woods, and near logs. III, 5; II, 1, 2; II, 5; IV, 4.

Juncaceae—Rush Family.

196. *Juncus effusus* L. Along old road to "Island mine," and in shallow water at upper end of Rock Harbor. III, 3.

Melanthaceae—Bunch-Flower Family.

197. *Tofieldia palustris* Huds. Asphodel. Rocks at Scovill Point, IV, 1.

189. *Uvularia perfoliata* L. Perfoliate Bellwort. Rich, moist woods. Scattered.

Liliaceae—Lily Family.

199. *Lilium philadelphicum* L. Red, or Wood Lily. Common in drier parts of woods; even occurs as a rock crevice plant on the small islands in Rock Harbor.

Convallariaceae—Lily-of-the-Valley Family.

200. *Clintonia borealis* (Ait.) Raf. Yellow Clintonia. Common everywhere in moist, rich woods; very abundant in places. I, 3; IV, 4; V, 4; V, 5.

201. *Vagnera trifolia* (L) Morong. Three-leaved Solomon's Seal. Frequent in forest margins of bogs, and in cool, moist woods. I, 4; II, 2; V, 5.

202. *Unifolium canadense* (Desf.) Greene. False Lily-of-Valley, Two-leaved Solomon's Seal. Rather open patches in rich, moist woods. I, 4; II, 2.

203. *Streptopus amplexicaulis* (L) DC. Clasping-leaved Twisted-stalk. Woods along portage to Siskowit Lake (V, 9).

204. *Trillium grandiflorum* (Michx.) Salisb. Showy, White Trillium. Flood plain of Washington Creek.

Iridaccae—Iris Family.

205. *Iris versicolor* L. Larger Blue Flag. Common in low wet places, as lake and bog margins. V, 5; III, 5; II, 5.

Orchidaceae—Orchid Family.

206. *Cypripedium reginae* Walt. Showy Ladies-Slipper. Wet places in woods: not abundant.. II, 1; near II, 5.

207. *Cypripedium hirsutum* Mill. Larger Yellow Ladies-Slipper. In drier parts of woods than preceding. IV, 4.

208. *Orchis rotundifolia* Pursh. Small Round-leaved Orchild. Rare: tamarack forest.

209. *Habenaria orbiculata* (Pursh) Torr. Large Round-leaved Orchid. Rich woods near IV, 2; few localities.

210. *Habenaria obtusata* (Pursh) Richards. Small Northern Bog Orchid. Fairly common in forested bog margins, and bog forests. I, 4; II, 2; V, 5.

211. *Habenaria hyperborea* (L) R. Br. Tall Leafy Green Orchid. Bogs and wet woods: margin of Sumner Lake, II, 5.

212. *Habenaria dilatata* (Pursh) Hook. Tall White Bog Orchid. Trembling bog margins of Forbes and Sumner Lakes, very abundant in latter place. II, 5; III, 5.

213. *Habenaria psycodes* (L) Gray. Smaller Purple-fringed Orchid. Associated with *H. dilatata* as given above, and also abundant. III, 5; II, 5.

214. *Pogonia ophioglossoides* (L) Ker. Rose Pogonia. Common along wet bog margins. III, 5; II, 5.

215. *Arethusa bulbosa* L. Arethusa. Wet bog margins. Not so common as preceding species.

216. *Gyrostachys romanzoffiana* (Cham.) MacM. Wet margins of Sumner Lake and Forbes Lake.

217. *Listera cordata* (L) R. Br. Heart-leaved Twayblade. Moist woods and ravines.

218. *Peramium repens* (L) Salisb. Lesser Rattle-snake Plantain. Cabin trail woods, V, 4, Siskowit.

219. *Peramium pubescens* (Willd.) MacM. Downy Rattle-snake Plantain. Rather dry woods. V, 4, III, 4.

220. *Peramium menziesii* (Lindl.) Morong. Menzies' Rattle-snake Plantain. Rich woods. V, 4; III, 4.

221. *Acroanthes monophylla* (L) Greene. (?) Sumner Lake margin. III, 5.

222. *Leptorchis liliifolia* (L) Kuntze. Large Twayblade. Moist woods and along bog margins. Woods of I.

223. *Leptorchis loeselii* (L) MacM. Loesel's Twayblade. Wet thickets and spring banks.
224. *Calypso bulbosa* (L) Oakes. Calypso. Wet, cool woods and ravines.
225. *Corallorhiza corallorhiza* (L) Karst. Early Coral-root. Rich, moist woods. Woods at upper end of Rock Harbor.
226. *Corallorhiza multiflora* Nutt. Large Coral-root. Fairly common in rich woods. I, 4; III, 4.

Santalaceae—Sandalwood Family.

227. *Comandra livida* Richards. Northern Comandra. Thin soil on rocks, and in open, xerophytic places. Pine ridge near Sumner Lake, III, 4. Fairly common.

Aristolochiaceae—Birthwort Family.

228. *Asarum canadense* L. Wild Ginger. Flood plain, Washington Creek. Only locality where noted.

Myricaceae—Bayberry Family.

229. *Myrica gale* L. Sweet Gale. Margin of bayou off Tobin's Harbor; wet rocks at Scovill Point. Also V. 6.

Caryophyllaceae—Pink Family.

230. *Sagina saginoides* (L) Britton. Arctic Pearl-wort. A hardy, low, rock crevice plant. I, 1.
231. *Alsine longifolia* (Muhl.) Britton. Long-leaved Stitch-wort. Scattered ruderal. II, 1.
232. *Silene antirrhina* L. Sleepy Catch-Fly. Side of Greenstone Ridge, and exposed xerophytic places. Not abundant. II, 3.

Nymphaeaceae—Water-Lily Family.

233. *Brasenia purpurea* (Michx) Casp. Water Shield. Open water in a few bogs; not abundant. Bog near Malone's fishing camp, V, II.
234. *Nymphaea advena* Soland. Large Yellow Pond-Lily. Margins and shallower water in a few bogs. III, 5.
235. *Castalia odorata* (Dryand.) W. & W. Sweet-scented White Pond-Lily. Abundant in Sumner Lake, III, 5, where it seems to grow in part on the uplifted "false bottom."

Ranunculaceae—Crowfoot Family.

236. *Caltha palustris* L. Marsh Marigold, Cowslip. Wet places in woods. Low woods at head of Rock Harbor, II, 1, 2; III, 5.
237. *Coptis trifolia* (L) Salisb. Gold-thread. Hummocks in wet woods and filled bogs, and in wet bog margins. Common.
238. *Actaea rubra* (Ait.) Willd. Red Baneberry. Sparingly distributed in woods. V, 4, 9; IV, 4.
239. *Aquilegia canadensis* L. Wild Red Columbine. Rocks near light-house at Rock Harbor. Not abundant.

240. *Anemone multifida* Poir. Red Wind-Flower. Rare. Rock shore of one island in Rock Harbor.

241. *Hepatica hepatica* (L) Karst. Round-lobed Hepatica. Woods: not abundant.

242. *Ranunculus abortivus* L. Kidney-leaved Crowfoot. Scattered as a ruderal. II, 1, and on Washington Club grounds.

243. *Ranunculus ovalis* Raf. Thin soil on rock islands. Upper end of Rock Harbor, III, 1; also near Siskowit cabin (V, 1).

244. *Ranunculus macounii* Britton. Macoun's Buttercup. Rare, one locality, near Siskowit cabin (V, 1).

245. *Thalictrum purpurascens* L. Tall Purple Rue. Moist, rich woods near Benson Brook (II, 1), and along Washington Creek.

Papaveraceae—Poppy Family.

246. *Capnoides sempervirens* (L) Borck. Pink Corydalis. Rocky, exposed places along the Greenstone. II, 3.

Cruciferae—Mustard Family.

247. *Thlaspi arvense* L. Field Penny Cress. Washington Club grounds. Only locality. Ruderal.

248. *Sisymbrium altissium* L. Tall Sisymbrium. Washington Club grounds: waste places. I, '04. Ruderal.

249. *Arabis brachycarpa* (T. & G.) Britton. Purple Rock Cress. Exposed rocks. Greenstone Ridge along the McCargo Cove trail. II, 3.

Sarraceniaceae—Pitcher Plant Family.

250. *Sarracenia purpurea* L. Pitcher Plant. Common in bog areas everywhere on island. I, 6; II, 2; II, 5; V, 5; V, 11.

Droseraceae—Sundew Family.

251. *Drosera rotundifolia* L. Round-leaved Drosera. Common along wet bog margins, especially III, 5.

252. *Drosera intermedia* Hayne. Spatulate-leaved Sundew. Bog margins, but generally in wetter parts than the preceding; often elevated on a short stem extension. III, 5.

253. *Drosera linearis* Goldie. Slender-leaved Drosera. Bog margins; fairly abundant. III, 5.

Saxifragaceae—Saxifrage Family.

254. *Saxifraga tricuspidata* Retz. Three-toothed Saxifrage. Fairly common as a crevice plant along the low rock shore. L, 1.

255. *Saxifraga aizoon* Jacq. Livelong Saxifrage. A rock shore crevice plant. Rare. V, 2.

256. *Saxifraga nivalis* L. Clustered Alpine Saxifrage. Exposed rock shores, growing on scanty soil. I, 1; V. 2.

257. *Mitella nuda* L. Naked, or Low Mitrewort. Very common in moist woods. I, 3. Woods at end of Rock Harbor and on forested islands.

258. *Parnassia palustris* L. Northern Grass of Parnassus. Bog margin of Sumner Lake. Sparingly distributed.

Grossulariaceae—Gooseberry Family.

259. *Ribes setosum* Lindl. Bristly Gooseberry. Shore of Siskowit Lake. Rare.

260. *Ribes prostratum* L'Her. Fetid Currant. Rich, moist woods; also one of rock islands at Rock Harbor. Fairly abundant.

261. *Ribes rubrum* L. Red Currant. Growing wild in abundance in vicinity of Siskowit Lake portage. V, 9.

Rosaceae—Rose Family.

262. *Opulaster opulifolius* (L) Kuntz. Ninebark. Occurs principally along the shores, often as a crevice plant on the rock islands, as well as on rocky shore of main land. I, 1; III, 1; V. 6.

263. *Rubus parviflorus* Nutt. White-flowering Raspberry. A very common and characteristic plant of clearings and burnings; also occurs in thickets and open parts of woods. VIII, '04.

264. *Rubus arcticus* L. Arctic Raspberry, or Bramble. Sparingly distributed in moist woods and filled bog areas.

265. *Rubus strigosus* Michx. Wild Red Raspberry. Found most abundant in the burned areas at head of Siskowit Bay.

266. *Rubus americanus* (Pers.) Britton Dwarf Raspberry. Occasional in woods; rather common in bog forests.

267. *Fragaria vesca* L. Sparingly distributed. I, 1.

268. *Potentilla arguta* Pursh. Tall White Cinquefoil. Common around light-house clearing at Rock Harbor as a ruderal. I.

269. *Potentilla monspeliensis* L. Rough Cinquefoil. Exposed rocks having scanty soil.

270. *Potentilla littoralis* Rydberg. Coast Cinquefoil. Fairly common as a rock crevice plant along main shore, and on small rock islands. I, 1.

271. *Potentilla tridentata* Soland. Three-toothed Cinquefoil. Very common as a rock crevice plant along shores and on small rock islands. I, 1; V, 2.

272. *Potentilla fruticosa* L. Shrubby Cinquefoil. Rocks at Scovill Point, IV, 1. Occasional shore crevice plant. I, 1.

273. *Comarum palustre* L. Purple Marsh Cinquefoil. One of the most common and most characteristic plants of all bog-lake margins, and contributing an important part toward the vegetative bog carpet.

274. *Waldsteinia fragariodes* (Michx.) Tratt. Barren or Dry Strawberry. Large patches on the side of the Greenstone range along McCargo trail. II, 3.

275. *Rosa acicularis* Lindl. Prickly Rose. Only species of rose found on island. Fairly common around light-house clearing and in open places.

Geraniaceae—Geranium Family.

276. *Geranium bicknellii* Britton. Bicknell's Cranebill. Rock crevice plant: also on rocks with thin soil covering. Few localities only. I, 1.

Polygalaceae—Milkwort Family.

277. *Polygala paucifolia* Willd. Fringed Polygala. Fairly common in rich, moist woods. I, 3; III, 4.

Empetraceae—Crowberry Family.

278. *Empetrum nigrum* L. Crowberry, Heath-berry. On exposed, nearly bare rocks at Scovill Point. IV, 1.

Anacardiaceae—Sumac Family.

279. *Rhus hirta* (L) Sudw. Staghorn Sumac. Sparingly distributed on higher parts of Greenstone. II, 3.

Hypericaceae—St. John's-wort Family.

280. *Triadenum virginicum* (L) Raf. Marsh St. John's-wort. Bog margin of Sumner Lake (III, 5); also margin of Forbes Lake (II, 5). Common.

Violaceae—Violet Family.

281. *Viola rotundifolia* Michx. Round-leaved Violet. Fairly common in rich, moist woods, especially near I, 6.

282. *Viola labradorica* Schrank. American Dog Violet. Few Specimens in low moist ground near shore at Siskowit Bay cabin, V, 1.

283. *Viola arenaria* DC. Sand Violet. Rocky shore near Siskowit cabin V, 1.

Onagraceae—Evening Primrose Family.

284. *Chamaenerion angustifolium* (L) Scop. Fireweed. Very abundant everywhere in burnings and clearings.

285. *Epilobium lineare* Muhl. Narrow-leaved Willow-Herb. Bog margin Sumner Lake, III, 5.

286. *Epilobium adenocaulon* Haussk. Northern Bog Willow-Herb. Wet soil near shore of Siskowit cabin, V, 1.

287. *Circaea Alpina*, L. Smaller Enchanter's Nightshade. Cool moist woods at head of Rock Harbor. Not common.

Pyrolaceae—Wintergreen Family.

288. *Pyrola chlorantha* Sw. Greenish-flowered Wintergreen. Rich, moist woods.

289. *Pyrola asarifolia* Michx. Liver-leaf Pyrola. Most common of the island pyrolas. Woods.

290. *Pyrola secunda* L. One-sided Wintergreen. Rich, moist woods. Not common.

291. *Pyrola minor L.* Lesser Pyrola. Woods. Scarce.

292. *Moneses uniflora* (L) A. Gray. One-flowered Wintergreen. Rather widely distributed in rich, moist woods, although nowhere abundant. I, 3, 4; III, 4; IV, 4.

293. *Chimaphila umbellata* (L) Nutt. Pipsissewa. Dry woods and exposed sunny places, as the pine ridge near Sumner Lake.

Monotropaceae—Indian Pipe Family.

294. *Monotropa uniflora* L. Indian Pipe. Quite abundant in rich, dark, moist woods. Unusually large, vigorous specimens in wet margin of woods beyond Cabin bog at Siskowit (V, 5).

295. *Hypopitys hypopitys* (L) Small. Woods at Siskowit Bay, V, 4. Rare.

Haloragidaceae—Water Milfoil Family.

296. *Hippuris vulgaris* L. Mare's Tail. Head of Rock Harbor in shallow water. III, 2.

Araliaceae—Ginseng Family.

297. *Aralia nudicaulis* L. Wild Sarsaparilla. Abundant everywhere in rich moist woods, where it is one of the characteristic plants of the mesophytic forest. V, 4.

298. *Aralia hispida* Vent. Bristly Sarsaparilla. One single colony on a burned-over island in Rock Harbor. I, 1.

Umbelliferae—Carrot, or Umbel Family.

299. *Heracleum lanatum* Michx. Cow Parsnip. Light-house clearing at Rock Harbor; also an old mine clearing along Rock Harbor. Ruderal. I, 7; V, 3.

300. *Cicuta bulbifera* L. Bulb-bearing Water Hemlock. Occasional in bog margins, as II, 5; III, 5.

301. *Pastinaca sativa* L. Wild Parsnip. Clearing at beginning of McCargo's trail.

Cornaceae—Dogwood Family.

302. *Cornus canadensis* L. Low, or Dwarf Cornel. Bunchberry. Very abundant in filled bog areas and in moist woods. Also occurring abundantly in open places. One of most common herbaceous plants on the island.

Cornus stolonifera (See tree and shrub list.)

Cornus circinata (See tree and shrub list).

Ericaceae—Heath Family.

303. *Ledum groenlandicum* OEder. Labrador Tea. One of the most characteristic bog shrubs. Common in bogs everywhere. I, 6; II, 2; II, 5; V, 5; V, 11.

304. *Kalmia glauca* Ait. Swamp Laurel. Fairly common in bogs, but nowhere so abundant as the preceding.

305. *Andromeda polifolia* L. Wild Rosemary. Abundant in nearly all the recently filled bogs.

306. *Chamaedaphne calyculata* (L) Moench. Dwarf Cassandra. A very characteristic and common shrub of nearly all the bogs.

307. *Arctostaphylos uva-ursi* (L) Spreng. Bearberry. Very abundant as a heath plant along the rock shore, and on the thinly-covered "rock openings." I, 1, 5 and V, 2.

Vacciniaceae—Huckleberry Family.

308. *Vaccinium uliginosum* L. Great Bilberry. Rocks at Scovill Point. IV, 1.

309. *Vaccinium pennsylvanicum* Lam. Low, or Pennsylvania Huckleberry. Abundant as a heath plant along shores, and on nearly bare mountain sides. V, 2; II, 3; IV, 8, and on some of the small islands at Rock Harbor.

310. *Chiogenes hispidula* (L) T. & G. Creeping Snowberry. Edge of bogs, and on sphagnum hummocks. I, 6; V, 5; II, 2.

311. *Oxycoccus oxycoccus* (L) MacM. Low Cranberry. Confined to wet, unforested bogs: only fairly abundant. I, 6; II, 2; V, 5, and bog near Malone's fishing camp, V, 11.

Primulaceae—Primrose Family.

312. *Primula mistassinica* Michx. Dwarf Canadian Primrose. A crevice plant along the rock shore. Not abundant. I, 1; IV, 1; V, 2.

313. *Lysimachia terrestris* (L) B. S. P. Bulb-bearing Loosestrife. Thinly soil-covered rock shore near Siskowit cabin, V, 1.

314. *Naumbergia thyrsifolia* (L) Duby. Tufted Loosestrife. Margin of Siskowit Lake near head of Trout Creek, V, 6.

315. *Trientalis americana* Pursh. American Star-Flower. Moist, rich woods. Sparingly distributed. I, 4; IV, 4; V, 4.

Gentianaceae—Gentian Family.

316. *Gentiana andrewsii* Griseb. Closed, or Bottled Gentian. A few specimens from the Siskowit cabin trail bog, V, 5. Rare.

317. *Tetragonanthus deflexus* (J. E. Smith) Kuntze. Spurred Gentian. Moist woods, head of Rock Harbor. Few localities only.

Menyanthaceae—Buck-bean Family.

318. *Menyanthes trifoliata* L. Buckbean. Abundant in wetter parts of bogs: very important contribution in the formation of the "bog carpet." II, 5, III, 5, and bog near V, 2.

Apocynaceae—Dogbane Family.

319. *Apocynum androsaemifolium* L. Spreading Dogbane. Washington Club grounds.

Convolvulaceae—Morning-glory Family.

320. *Convolvulus repens*, var. *pubescens*. Pubescent Bindweed. Nearly bare sides of the Greenstone along the McCargo Cove trail, II, 3.

Hydrophyllaceae—Water-leaf Family.

321. *Phacelia franklinii* (R. Br) A. Gray. Franklin's Phacelia. Few specimens taken on a thinly soil-covered rock elevation near Rock Harbor lighthouse.

Labiatae—Mint Family.

322. *Scutellaria laterifolia* L. Mad-Dog Skullcap. Along flood plain of Washington Creek.

323. *Scutellaria galericulata* L. Marsh Skull-Cap. Wet bog margins, as of Sumner (III, 5) and Forbes (II, 5) lakes.

324. *Prunella vulgaris* L. Self-heal. Clearings: occurs as a ruderal, Washington Club grounds, II, 1, etc.

325. *Clinopodium vulgare* L. Wild Basil. Woods on Greenstone along McCargo trail. Not abundant.

326. *Lycopus americanus* Muhl. Cut-leaved Water Hoar-hound. Wet bog margin of Sumner Lake. III, 5.

327. *Mentha canadensis* L. American Wild Mint. Near water's edge at Siskowit cabin, V, 1. Also on Washington Club grounds.

Scrophulariaceae—Figwort Family.

328. *Scrophularia leporella* Bicknell. Hare Firwort. Along Washington Creek.

329. *Veronica americana* Schwein. American Brooklime. Along Washington Creek on low ground.

330. *Castilleja acuminata* (Pursh) Spreng. Lance-leaved Painted-Cup. Common around light-house at Rock Harbor. Fairly abundant in open, moist places.

331. *Melampyrum lineare* Lam. Narrow-leaved Cow-wheat. Fairly common on dry, open, to partly shaded places. Exposed Norway Pine ridge near Sumner Lake; also occasional in open woods.

Lentibulariaceae—Bladderwort Family.

332. *Utricularia minor* L. (?) Lesser Bladderwort. In shallow water on bog marginal carpet at Sumner Lake (III, 5); also occurs at Forbes Lake (II, 5).

333. *Pinguicula vulgaris* L. Butterwort, Bog Violet. Rock pools or moist rocks near water's edge; fairly common. IV, 1; I, 1; V, 2.

Rubiaceae—Madder Family.

334. *Galium spurium* L. Lesser Cleavers. Low ground along Washington Creek.

335. *Galium triflorum* Michx. Sweet-scented Bed-straw. Woods along McCargo trail.

336. *Galium trifidum* L. Small Marsh Bed-straw. Wet bog margins of Sumner (III, 5) and Forbes (II, 5) lakes.

Caprifoliaceae—Honey-suckle Family.

337. *Sambucus pubens* Michx. Red-Berried Elder. Along Siskowit portage. Fairly common.

338. *Sambucus canadensis* L. American Elder. Light-house clearing at Rock Harbor.

339. *Viburnum acerifolium* L. Fairly common in woods. I, 3; III, 4.

340. *Viburnum paucifolium* Pyl. Few-flowered Cranberry. Moist woods: abundant. I, 3.

341. *Linnaea borealis* L. Twin-flower. Very common in woods and partial clearings. Even occurs at I, 1, as a rock crevice plant. Widely distributed.

342. *Lonicera dioica* L. Glaucous Honey-suckle. Occasional in woods. I, 3.

343. *Lonicera ciliata* Muhl. American Fly Honey-suckle. Fairly common in woods. I, 3; III, 4; IV, 4, 8; V, 4.

344. *Lonicera hirsuta* Eaton. Hairy Honey-suckle. Rare: in woods.

345. *Lonicera involucrata* (Richards) Banks. Involucred Honey-suckle. Border of lighthouse clearing, and in open parts of woods. Fairly common. I, 3.

346. *Diervilla diervilla* L. Bush Honey-suckle. A very abundant and characteristic shrub of burnings, clearings, and natural openings in woods. 1, 2 (and on rock islands in Rock Harbor), II, 1, 3; III, 4; IV, 4; V, 2, 3.

Campanulaceae—Bell-Flower Family.

347. *Campanula rotundifolia* L. Blue Hare-bell. Common rock crevice plant on rock shore and small rock island. Also growing on thin soil along the shore. I, 1; V, 2.

348. *Campanula aparinoides* Pursh. Marsh Bell-flower. Common in wet bog margins of Sumner (III, 5) and Forbes (II, 5) lakes.

349. *Lobelia kalmii* L. Brook, or Kalm's Lobelia. A rock crevice plant, and on moist rocks near water's edge. Common. I, 1; IV, 1; V, 2.

Chicoriaceae—Chicory Family.

350. *Lactuca pulchella* (Pursh) DC. Large-flowered Blue Lettuce. Noted in one locality only, rock clearing on side of Greenstone along the McCargo trail. II, 3.

351. *Hieracium umbellatum* L. Narrow-leaved Hawkweed. On rocks or in rock crevices. V, 2.

352. *Nabalus albus* (L) Hook. White Rattle-snake Root. Woods: not abundant. Forest along Siskowit portage. V. 9.

353. *Nabalus racemosus* (Michx.) DC. Glaucous White Lettuce. Rocks and rock crevices along shore. IV, 1; V, 2.

Compositae—Composite Family.

354. *Eupatorium pupureum L.* Joe-Pye Weed, or Purple Boneset. In moist land near creek, upper end of Rock Harbor, III, 3.

355. *Solidago virgaurea* L. var. (?) European Golden-rod. Rock crevices, and thin soil on rocks and rock islands. I, 1.

356. *Solidago neglecta* T. & G. Swamp Golden-rod. Fairly common in most of the wet bogs. I, 6; III, 5; V, 5.

357. *Solidago juncea* Ait. On thinly soil-covered rock surfaces. Rock Harbor, I, 5.

358. *Solidago uliginosa* Nutt. Siskowit cabin trail bog. V, 5.

359. *Aster macrophyllus* L. Large-leaved Aster. Very abundant and characteristic in nearly all clearings, and in natural rock openings in woods. Often forms large colonies.

360. *Aster ptarmacoides* (Nees) T. & G. Upland White Aster. Fairly common on small rock island, and as a rock shore crevice plant, the only crevice aster. I, 1; IV, 1; V, 2.

361. *Aster hirsuticaulis* Lindl. Hairy-stemmed Aster. Woods along Washington Creek; one locality only.

362. *Anaphalis margaritacea* (L) B. & H. Large Pearly Everlasting. Dry soil, and rock clearings along Greenstone (McCargo trail). II, 3, and on Washington Club grounds.

363. *Artemisia canadensis* Michx. Canada Wormwood. Crevice plant along rock shore, and on small islands in Rock Harbor. I, 1; V, 2.

364. *Senecio balsamitae* Muhl. Balsam Groundsel. Common rock crevice plant on Rock Harbor islands, and elsewhere along the rock shore. I, 1; III, 1; IV, 1; V, 2.

SUMMARY.

Species of lichens	43
Species of mosses	38
Species of Pteridophytes	35
Species of Spermatophytes	248
Total	364

REFERENCES.

Wheeler, W. A.
1901. Notes on Some Plants of Isle Royale. Minn. Bot. Studies, 2, pp. 619-620.

Ruthven, A. G.
1906. Notes on the Plants of the Porcupine Mountains and Isle Royale, Michigan. Rep. Mich. Geol. Survey for 1905, pp. 86-92.

ANNOTATIONS ON CERTAIN ISLE ROYALE INVERTEBRATES.

DR. CHAS. C. ADAMS.

The following annotated list of Isle Royale invertebrates includes the groups which have not been made the basis for separate papers by specialists. For the determination of these I am indebted to the following persons: Prof. N. A. Harvey, the Sponge; Dr. T. H. Montgomery, Hair-worms; Prof. Frank Smith, Earthworms; Dr. J. Percy Moore, Leeches; Miss Ada Weckel, Amphipods; Dr. Harriet Richardson, Sow-bug; Mr. Nathan Banks and Mr. J. H. Emerton, Spiders; Dr. J. W. Folsom, Spring-tail; Mr. E. B. Williamson, Dragonflies; Prof. Herbert Osborn and Mr. J. B. de la Torre Bueno, Hemiptera; and to Prof. A. J. Snyder and Dr. James Fletcher, Lepidoptera.

In general, in addition to the field notes which include those made by Dr. H. A. Gleason and myself, the geographic range has been outlined and a selected series of references is given for the convenience of the student of the Michigan fauna. The insects were largely collected by Dr. Gleason, the writer, and B. F. Savery who collected insects about the camps, but all members of the party aided in the collection of the specimens. The field numbers are indicated in parentheses, preceded by G in the case of Dr. Gleason's numbers and A in my own.

An examination of these lists will reveal their incomplete character, as an effort was made to make representative rather than complete collections of the groups. On account of the small amount of zoological information which we possess from Isle Royale it has been thought desirable to make the determinations of the collections as complete as circumstances would allow.

PORIFERA.

Spongillidae.

Spongilla lacustris (Linn.). Fresh Water Sponge. A small colony of this sponge was found on July 26 in shallow water near the head of Rock Harbor (III, 3) by Gleason. Prof. N. A. Harvey examined the specimen and makes the following comments: "Small encrusting sponge, with a tendency to branch. One branch cylindrical, full of gemmules. Skeleton spicules smooth, pointed, slightly curved, numerous. Dermal spicules, few, half as long as skeleton spicules, densely spined, spines short, more numerous towards the ends, slightly curved. Gemmules with very thin membrane, destitute of spicules, foramen oval.

"This sponge is evidently a weak form of *Spongilla lacustris* (Linn.). It is very close to the *paupercula* of Bowerbank. There can be no question about the identity of this sponge, although it is somewhat unusual to find gemmules so well developed in July. It developes its gemmules ordinarily very late in the fall. The spicules on the gemmule appear to be wholly wanting, and the dermal spicules are not numerous.

The specimen is too small to show the peculiar branching habit very distinctly."

A large quantity of this sponge was also secured during 1904 in the Porcupine Mountains, Ontonagon county, Mich., by N. F. Macduff. The specimens came from Carp Creek (Sta. VI) in August. Concerning these specimens Prof. Harvey also remarks: "Skeleton spicules smooth, slightly curved, pointed at both ends. Dermal spicules half the length of skeleton spicules, or shorter, spinous spines numerous but short. Gemmules not well developed. The branches containing few or none. The encrusting portion of the sponge manifesting some. Gemmule spicules wanting. The gemmule crust very thin, or altogether wanting. Its branching character is well marked, and the small size of the branches indicate the weak form which seldom shows many gemmules or in which the gemmule spicules are seldom well developed. In consequence of the size and striking branched habit of this sponge it is the one that is usually first found by collectors. I am surprised to find any gemmules matured in these sponges at the season when these were collected."

NEMATODA.

Gordiidae.

Gordius aquaticus robustus (Leidy) Montg. Hair Worm. This species of hair worm was fairly abundant: specimens were taken at the head of Tobin Harbor (IV, 7) among *Potamogeton perfoliatum* on July 20: among sedges at the head of a small island in the Harbor (IV, 6), and on the beach at our camp on Siskowit Bay (V, 1) August 3 and 6. Both sexes are represented in our series. cf. Montgomery, '98, pp. 30-31.

Geographic Range. Bay of Fundy; Maine; Massachusetts; Maryland; District of Columbia; New York; Pennsylvania; Montana; Michigan; Kansas. The typical form occurs in Europe.

During August, 1903, Mr. A. G. Ruthven secured specimens of *Gordius lineatus* Leidy, in a spring in the Porcupine Mountains (Station VI), Ontonagon county, Mich. cf. Montgomery, '98, p. 32. This species seems to frequent springs. It is recorded from New York, Pennsylvania and Maryland.

REFERENCES.

1898. Montgomery, Jr., T. H. The Gordiacea of Certain American Collections with Particular Reference to the North American Fauna. Bull. Mus. Comp. Zool., 32, pp. 23-59.

1899. Gordiacea (Hair worms). Amer. Nat., 33, pp. 647-652.

HIRUDINEA.

Glossiphonidae.

Glossiphonia complanata (Linn.). One specimen of this leech was taken in a tamarack swamp (V, 5) on August 12. Moore ('01, p. 493) states that it abounds under stones in running water and "feeds chiefly on small snails and annelids."

Geographic Range. Connecticut; Lake Ontario; Lake Erie; Ontario; Ohio; Michigan; Illinois; also found in Europe.

Hirudinidae.

Macrobdella decora (Say) Verrill. This species was quite abundant at a marshy margin of Sumner Lake (III, 5), where many specimens were taken during July. This is a large species and easily recognized by its dark brown dorsal surface and reddish colored ventral surface. They are very graceful and conspicuous objects when seen swimming. One specimen was taken upon a frog. Moore (1901, p. 511) reports this species as a true blood-sucker and that it is frequently found gorged.

Geographic Range. Maine; New York; Connecticut; Virginia; Michigan; Minnesota; Illinois; Kansas; Nebraska.

Haemopsis grandis Verrill. One specimen was taken, July 5, on the south shore of Siskowit Lake (V, 6). This is a mud leech and at times leaves the water in search of earthworms (Moore, '01, p. 527). Also taken in 1904 by Ruthven at Lake Desor (VII, '04), Ruthven, '06, p. 51.

Geographic Range. Connecticut; Lake Huron; Michigan; Lake Superior (Verrill, '74, p. 672); Yellowstone Park; Kansas; Alaska (*H. marmoratis* Moore, '98, p. 560); Michigan; Illinois; Nebraska.

Herpobdellidae.

Herpobdella lateralis (Verrill) Moore. On the south shore of Siskowit Lake (V, 6) one specimen was taken August 5, and another specimen was taken July 14, in shallow water, at the head of Rock Harbor (III; 3).

The type of this species came from near the northern shore of Lake Superior.

Geographic Range. Maine; Connecticut; Lake Huron; Lake Superior; Colorado, (Verrill, '74, p. 675).

Nephalopsis obscura Verrill. Egg capsules of these leeches were taken July 27 at Sumner Lake (III, 5), on a yellow water lily leaf (*Nymphaea advena*) and apparently young were associated with them; and similar capsules were also found on *Potamogeton* leaves. A capsule was also found in Rock Harbor at Neutson's Resort (IV, 5) also in a swampy bayou off Tobin's Harbor (IV, 3) on July 21. Specimens of the leeches themselves were taken in Siskowit Bay on the beach at our camp (V, 1), in Siskowit Lake at a small island on the south shore (V, 6) and at the swamp margin of a pond in the yellow water-lily and *Potamogeton zone* (V, 11). Also taken in 1904 by Ruthven at Lake Desor (VII, '04), Ruthven, '06, p. 51.

Geographic Range. Wisconsin; Colorado (Verrill, '74, p. 674); Michigan.

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OLIGOCHAETA.

Lumbricidae.

Helodrilus (*Allolobophora*) *caliginosus* (Savigny), nearer to *typicus* than to *H.* (*A.*) C. *trapezoides* (Ant. Dug.). These earthworms were taken along the beach near the light-house at Rock Harbor (I, 1) July 9, and in a "rock clearing" (I, 2) on July 13, and also at the outlet of Siskowit Lake (V, 9) on August 15. An undetermined species was taken in the shallow humus on the rock beach under *Cladonia* (V, 2).

Geographic Range. Northern Europe and North America. (Michaelsen, '00, p. 483).

Lumbricus terrestris Müll. A large specimen was taken from the mouth of a Garter Snake (*Thamnophis sirtalis*) found in a clearing which was formerly the location of the Ransom settlement (II, 1). The snakes were very abundant near the shore in the grass. It is not improbable that these earthworms were introduced at this locality. Other specimens, doubtfully referred to this species came from the balsam-spruce forest (I, 3), where there was also found an Enchytraid. (G. 140).

Geographic Range. Europe; New England; Illinois; Mexico. (Michaelsen, '00, p. 512, '03, p. 144).

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AMPHIPODA.

Gammaridae.

Eucrangonyx gracilis (Smith). Among the dark colored vegetable debris on the north shore of Sumner Lake (III, 5) this species was found, July 29; also in a small stream flowing from a tamarack-spruce swamp (V, 5) on August 8, in the *Potamogeton* and *Nymphaea advena* zone of a small pond, and also back from the pond in small footprint-like pools of water in the buck-bean (*Menyanthes trifoliata*) and sedge zone. (A. 126, 128, 77, 97).

Hyalella knickerbockeri (Bate). Taken at the west end of Rock Harbor in the bulrushes about the mouth of a small stream (III, 3) on July 26, (G. 159). Other specimens were taken in 1904 at Lake Desor ('04, VII) on August 30; and on water plants in Washington river ('04, II) on August 18.

Gammarus limnaeus Smith. Found in the same conditions as the above species (III, 3) and in abundance.

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ISOPODA.

Oniscidae.

Cylisticus convexus (DeG.). One specimen of this sow-bug was taken at camp at the Light-house (I, 7) on July 15. (G. 99). Another specimen was taken July 2, at Mackinaw Island, Straits of Mackinac, Michigan. cf. Richardson, '05, p. 609.

Geographic Range. Massachusetts; New York; Washington, D. C.; Ohio; Michigan; Illinois; New Mexico; also Norway; Sweden; Denmark; British Isles; Germany; Bohemia; Holland; Belgium; France; Turkey. This species may have been carried to Isle Royale by man.

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1905. Richardson, H. A Monograph of the Isopods of North America. Bull. No. 54, U. S. Nat. Museum.

ACARINA.

Rhyncolophidae.

Rhyncolophus simplex Bks. This mite was found in the thin soil and debris beneath the mats of bearberry in a dry rock clearing (I, 2). Banks, '04, p. 30.

Hydrachnidae.

Limnochares extendens Say. This water mite was taken from the water in the sedge zone near the open water at Sumner Lake (III, 5).

Geographic Range. "It occurs in northern states, from Maine to Michigan, perhaps farther west." (Banks, in letter).

ARACHNIDA.

Phalangiidae.

Lacinius ohioensis Weed. Only three specimens of this Harvest Spider were taken, one was found under stones on a shallow soil among the Jack Pines (I, 5) in a very hot and dry locality; the second from the margin of the sedge zone about a pond (V, 11), and the third from under *Cladonia* on a rocky beach with a very shallow soil (V, 2).

Geographic Range. Ohio, Illinois, Weed, '93, p. 559; Michigan.

Dictynidae.

Amaurobius bennetti Blk. A few specimens were taken under dry bark in the hardwoods on a ridge north of the Club House at Washington Harbor (V, '04); also from under the bark of decayed log in the maples

on the Desor Trail (III, '04). In the moist vegetable mold in the balsam-spruce forest (I, 3) and under the bark of dead trees near the rock clearing at the camp on Siskowit Bay (V, 3). One was found in the mouth of a Winter Wren shot by McCreary (II, 1). In the clearing at Benson Brook (II, 1), and in the "rock clearing" at camp on Siskowit Bay (V, 3).

Geographic Range. Canada, Marx, '90, p. 510; Porcupine Mountains, Michigan.

Drassidae.

Drassus neglectus Keys.=*D. saccatus*, Emerton, '02, p. 6. One specimen was taken from under a stone, upon the jack pine ridge where the soil was very shallow and the heat intense during the middle of the day (I, 5). It was enclosed in a rather compact close fitting web. Also taken from the margin of a pond among the vegetation (V, 11). One collected on the rock ridge north of the light-house (I, 2) was in a small pocket-like web about 2 by 2.5 cm. in a cavity under a flat stone, surrounded by moist soil, at a depth of about 6 cm. (Gleason).

Geographic Range. New Hampshire, Slosson, '98, p. 247; Michigan; Dist. Columbia, Marx, '96a, p. 154.

Gnaphosa brumalis Th. The only specimen (G. 22) was taken in a small *Cladonia* clearing on the north side of Conglomerate Bay (I, 2) near the beach.

Geographic Range. Labrador; Anticosti Island, Quebec; White Mts., above tree limit, N. H.; Ithaca, N. Y.; Massachusetts; Colorado; Laggan, Alberta. cf. Emerton, '94, p. 413; Banks, '95, pp. 417, 421; Marx, '90, p. 508. It is not unlikely that the New York and Massachusets localities are from "boreal islands"—swamps or cool ravines, and are thus outliers from the principal range of this form to the northward. Alaska, Marx, '96a, p. 189.

Agriopidae.

Linyphia phrygiana Koch. One specimen was taken at our camp at the Light-house (1, 7). Emerton, '02, p. 141.

Geographic Range. Gaspe, Quebec; Mt. Washington, N. H.; Maine; Mass.; New York; Connecticut; Colorado; Rocky Mts. of Canada; Calif.; probably all over the United States and Northern Europe. Emerton, '94, p. 409, and '82, p. 63; Banks, '95, p. 425.

Tetragnatha extensa Linn. One specimen was taken on the window sill at the Light-house (I, 7). Emerton, '02, 201, 203.

Geographic Range. Labrador; Mass.; New York, Marx, '90, p. 552; Anticosti Island, Quebec; Saskatchewan River; White Mts., N. H.; Adirondack Mts., N. Y.; Connecticut; Dist. Columbia; Alaska; Siberia; Lapland; Europe, Emerton, '04, p. 406; Beaver Island, Mich., Pettit, '01, p. 39; Calif., Collidge, Can. Ent. 39, p. 376. Marx. '96a, p. 196.

Epeira patagiata Clerck. Taken in the cassandra zone of a tamarack swamp (V, 5). Emerton, '02, p. 160. Comstock, '03, p. 38.

Geographic Range. Lapland; Labrador; New Foundland; New Hampshire; New York; Pennsylvania; Maryland; District of Columbia; Virginia; Illinois; Montreal, Anticosti Island, Quebec; Lake of the Woods; Saskatchewan River; Colorado; British Columbia; Washing-

ton; Oregon; Sitka, Alaska; Europe. Emerton, '04, p. 404, and '84, p. 305; Slosson, '98, p. 248; Banks, '95, pp. 417, 425. Marx. '96a, p. 194. It seems probable that the most southern localities of this species are confined to some restricted habitat.

Thomisidae.

Ebo latithorax Keys. One specimen was taken on the beach near the Light-house (I, 1). Emerton, '02, p. 38.

Geographic Range. Mass.; New York, Emerton, '92, p. 378; Virginia; District of Columbia; Maryland; Utah. Marx, '90, p. 558.

Clubionidae.

Clubiona riparia Koch. One specimen was taken in the vicinity of Tobin Harbor (IV).

Geographic Range. Maryland, Marx. '90, p. 512; New Hampshire, Slosson, '98, p. 247; Colorado, Banks, '95, p. 422. Dist. Columbia, Marx. '96, p. 155.

Agelenidae.

Tegenaria derhami (Scop.). Found in the hardwood forest on the ridge east of the tamarack swamp (V, '04) back of the Club House at Washington Harbor. Emerton, '02, p. 96, and Marx, '90, p. 516.

Geographic Range. Labrador; Gaspe, Quebec; "A common house spider in North America and Europe," Emerton, '94, p. 411; New Hampshire, Slosson, '98, p. 247; Colorado, Banks, '95, p. 422; Calif., Collidge, Can. Ent., 39, p. 375. Marx. '96a, p. 190. Dist. Columbia, Marx. '96, p. 155. Indiana, Fox, '93, p. 268. Probably introduced (Emerton).

Coelotes sp. A specimen, too young for specific identification, was taken in a rock clearing (I, 2) near the Light-house. It spins a pocket just about large enough for its body beneath loose rocks.

Cicurina arcuata Keys. Where the soil was very thin on the jack pine ridge (I, 5) one specimen was taken under a stone and a female was found with a white disk-like cocoon containing a large number of young white spiders. A specimen belonging to this genus was found along the trail through the balsam forest in leaf mold at Siskowit Bay (V, 4), but it is too young for specific determination. It spins a small pocket-like web beneath flat stones. Frequents the dead leaves of forests (Emerton).

Geographic Range. Labrador; New Hampshire; Penn.; District of Columbia; Virginia; Lake Superior; Minnesota; Illinois; Colorado, Marx, '90, p. 516; '96*a*, p. 190, '92 ,p. 155.

Pisauridae.

Dolomedes idoneus Montg. This large spider was taken at the log cabin of the Washington Club at Lake Desor (VII, '04) (A. 139).

Geographic Range. Lake Champlain; Conn. (Emerton); Penn.: Michigan.

Lycosidae.

Lycosa frondicola Emer. One specimen was taken about camp at the Light-house (I, 7).

Geographic Range. Conn., Marx, '90, p. 561; New Hampshire; Slosson, '98, p. 248; Penn., Stone, '90, p. 426; Michigan; Dist. Columbia, Marx, '96, p. 160. Indiana, Fox, '93, p. 269.

Lycosa pratensis Emer. On a gravelly beach near the Light-house (I, 1) dragging an egg-case with it, in the rock clearing (I, 2) and on the dry Jack Pine Ridge (I, 5) were the situations in which this species was taken. Emerton, '02, p. 69.

Geographic Range. Anticosti, Quebec; White Mts., N. H.; Mass.; Conn.; Porcupine Mountains, Mich.; Lake of the Woods; Laggan, Alberta. Marx, '90, p. 563 and Emerton, '94, p. 422.

Lycosa kochi Keys. This was an abundant species, found upon the beach near the Light-house (I, 1); in a rock clearing adjoining the beach (I, 2) (G, 71), and about the camp on Siskowit Bay (V, 3) where one had been captured by a wasp. One with an egg-case attached was buried under half an inch of soil on a rock ridge (I, 2). Emerton, '02, p. 74.

Geographic Range. Mass.; Conn.; Penn.; New Jersey; Dist. Columbia; Michigan. Emerton, '85, p. 486; Stone, '90, p. 426; Marx, '96. p. 160.

Pardosa glacialis Thor. Found quite abundantly running about over the wet sphagnum on the north shore of Forbes Lake (II, 5); many were carrying cocoons. Others were secured among the open cassandra, tamarack and spruce zone about a pond (V, 11). Several other specimens were taken running about with cocoons in the *Cladonia-Juniper procumbens* and bearberry belt on a sloping rock beach (V, 2). Emerton, '02, p. 80.

Geographic Range. Greenland; Labrador; White Mts., N. H.; Massachusetts (Emerton); Conn.; Laggan, Alberta; Emerton, '94, p. 425; New Mexico, Psyche, 9, p. 123, Marx, 96*a*, p. 197. Found near Ann Arbor, Mich. in a tamarack swamp (Miss Jean Dawson), thus clearly indicating the boreal island character of such a habitat.

Pardosa groenlandica Thor. This was apparently the most common species of spider collected. Many were found running about over the rocky, gravelly or sandy beaches (I, 1) with cocoons (G. 16, 38, 39, 30, 46). A specimen was also taken on the open heath beach on the south shore near Siskowit Bay (V, 2). Emerton, '02, p. 79.

Geographic Range. Greenland; Labrador; Anticosti Island, Quebec; White Mts., above the tree limit among stones (Emerton), N. H.; Lake of the Woods; Laggan, Alberta; Idaho; Colorado; Washington; Oregon; Alaska. Emerton, '94, pp. 400, 423; Banks, '98, p. 16, '95, p. 430; Marx, 96a, p. 197.

Pardosa sternalis Th.=*luteola* Em. All the specimens of this species were taken in open areas in a small *Cladonia* clearing near the beach on the north side of Conglomerate Bay (I, 2), and crawling about over the nests of the ant *Formica fusca* (V, 3); the heath beach near Siskowit Bay (V, 2) (A. 107) and in the open area about our camp on Siskowit Bay (V, 3) (G. 225). Most of the females carried cocoons.

Geographic Range. Colorado, Banks, '95, p. 429. Mt. Washington, N. H. On mosses and lichens (Emerton).

Pardosa lapidicina Emer. This was also a beach spider (I, 1) (G. 25, 38 (2)). The cocoons are very large in proportion to the size of the female and are flattened. Emerton, '02, p. 78. Lives among stones (Emerton).

Geographic Range. Gaspe, Quebec; Massachusetts; Connecticut; Pennsylvania. Emerton, '02, p. 79, states that this species "lives among stones in the hottest and dryest places from Connecticut to Labrador." Marx, '90, p. 565; Stone, '90, p. 431.

Pardosa tachypoda Thor. Found running over the bare rocks on the top of the jack pine ridge (I, 5), and carrying cocoons (A. 21). Emerton, '02, p. 81.

Geographic Range. Labrador; Mt. Washington, N. H.; Adirondack Mts., N. Y.; Manitou, Colo. Emerton, '85, p. 493, and '94, p. 401.

Salticidae—Attidae.

Phiddippus borealis Bks. One specimen of this jumping spider was found under loose stones on moist earth on the jack pine ridge (I, 5).

Geographic Range. New Hampshire, Banks, '95, p. 96, Slosson, '98, p. 249; Maine; New York, Banks (in letter).

Habitat Preferences. Reviewing the preceding list of mites and spiders the following habitat preferences appear to be indicated:

I. Beach, rocky, bouldery or sandy.
- *Lycosa pratensis* (also dry openings).
- *Lycosa kochi.*
- *Pardosa groenlandica.*
- *Pardosa sternalis* (also dry openings).
- *Pardosa lapidicina.*
- *Pardosa glacialis* (also in sphagnum bogs).

II. Dry openings, rock or shallow soil, heath-juniper—Cladonia plant society represented by I, 5; V, 2.
- *Rhyncolophus simplex.*
- *Lacinius ohioensis* (in swamp also).
- *Gnaphosa brumalis.*
- *Drassus neglectus* (in swamp also).
- *Coeletes* sp.
- *Cicurina arcuata.*
- *Lycosa pratensis.*
- *Lycosa kochi* (also beach).
- *Pardosa sternalis* (on beach also).
- *Pardosa tachypoda.*
- *Pardosa glacialis.*
- *Phidippus borealis.*

III. Wet places—as sphagnum swamps.
- *Epeira patagiata* (cassandra zone).
- *Pardosa glacialis* (also dry openings).
- *Drassus neglectus* (also dry openings).
- *Lucinus ohioensis* (also dry openings).

IV. Mesophytic forest—balsam-spruce or hardwoods.
Amarobius bennetti.
Tegenaria derhami.

V. About Camps.
Linyphia phrygiana.
Dolomedes idoneus.

From the above tabulation it is evident that, if the collections are representative, most of the spiders prefer the open places, the beach, rock openings or open parts of swamps, the most marked preference being for dry openings. It thus appears that as the forests encroach upon these areas the spider habitats become more restricted. The genus *Pardosa* seems quite characteristic of the open places. The general *Arachnid* successions are thus suggested in outline as follows: from beach types and rock openings to the forest; inland from the aquatic types and swamp forms to the forest. Particular attention is directed to the following habitats which deserve special attention for their bearing on succession; these are the birch-aspen border and clearing society, and glades or openings in the forest and the forested swamps. An examination of the literature clearly shows that the habitats of spiders have received but little attention. This is an excellent field for study and one certain to give interesting and valuable results.

Geographic Notes. The following nine species of Isle Royale spiders have been recorded from Labrador: *Gnaphosa brumalis, Tetragnatha extensa, Tegenaria derhami, Cicurina arcuata, Epeira patagiata, Pardosa glacialis* (also Greenland), *Pardosa groenlandica* (also Greenland), *Pardosa lapidicina* and *Pardosa tachypoda.*

The following fourteen species have been reported from New Hampshire: *Drassus neglectus, Gnaphosa brumalis, Linyphia phrygiana, Tetragnatha extensa, Epeira patagiata, Clubiona riparia, Tegenaria derhami, Dolomedes idoneus, Lycosa frondicola, Lycosa pratensis, Pardosa glacialis, Pardosa groenlandica, Pardosa tachypoda* and *Phidippus borealis.*

The following species are found in the mountains of Colorado: *Gnaphosa brumalis, Epeira patagiata* and *Pardosa groenlandica,* (Banks, '95). They also occur in New Hampshire, Labrador, and frequent open places.

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INSECTA.

Entomobryidae.

Tomocerus niger Beurl. Specimens of this spring-tail (G. 140) were taken July 24, in the balsam-spruce forest (I, 3).

This species has an extensive range; through Europe, Siberia, Alaska, California, Minnesota, Isle Royale, Michigan. cf. Folsom, 1902, Proc. Wash. Acad. Sciences, IV, p. 97; Guthrie, 1903, The Collembola of Minnesota, p. 81.

HEMIPTERA.

Corisidae.

Corixa sp. Nymphs were taken in the rock pools on the beach (I, 1) (G. 73, 74, 75); in Summer Lake (III, 5), (G. 175); and in the pond in a tamarack-spruce swamps (V, 11) (126. A).

Belostomatidae.

Belostoma sp. Nymphs, but no adults, were secured at Sumner Lake (III, 5) (77 A.); and in the pond in the tamarack-spruce swamp (V, 11) (126 A) on August 16.

Saldidae.

Salda ligata Say. On August 10 these shore bugs were running about in numbers on the bare rock beach, just beyond the reach of the waves, on the south shore near the mouth of Siskowit Bay (V, 2) (106 A). "Common over eastern United States. These specimens are darker than most in my collection but seem to agree very perfectly with descriptions of Say and Uhler." H. Osborn.

Hydrobatidae.

Gerris remigis Say. This member of the surface film fauna was found on July 14 on the bulrush zone and delta near the head of Rock Harbor (III, 3); in rock pools at Scovill Point on July 19 (33 A), where it was very abundant and represented by unwinged adults and nymphs; in rock pools on the south shore near Siskowit Bay (V, 2) on August 9 and 14 by adults and nymphs (103 A, 117 A); and on Lake Desor (VII. '04) on August 20 (139 A) by both young and adults.

Gerris rufoscutellatus Latr. This species of water strider, in company with *G. remigis*, was taken from rock pools at Scovill Point (IV, 1) on July 19 (33 A). The specimens are winged. Also from the rock beach pools on the south shore (V, 2) on August 14 (117, A), and from a pond surrounded by a tamarack-spruce bog (V, 11) on August 16 (126 A).

Gerris marginatus Say. This third species of strider was found only at Sumner Lake (III, 5) on July 28 (G. 175), and was represented by nymphs and adults.

Gerris sp? Nymphs were taken in a rock pool at Tobin Harbor (IV, 2) on July 19 (30 A), and on a small stream at the head of a bog (V, 5) near Siskowit Lake (95 A).

Aradidae.

Aradus abbas Berg. One specimen was taken on August 7 about camp on Siskowit Bay (V, 3).

Lygaeidae.

Lygus pratensis L. Taken about camp at the Light-house (I, 7) July 11. "One of the dark colored varieties. The species has a wide distribution in both Europe and North America." H. Osborn.

Pamera sp. Also taken about camp at the Light-house (I, 7) on July 23. "Apparently an undescribed species." H. Osborn. (136 A).

Cicadidae.

Tibicem rimosa Say. var. This cicada was abundant upon the hot jack pine ridge (I, 5) and among the birches at its base. Adult specimens and a nymph skin were taken on July 8 (G. 28), 10 (G. 44) and 17 (G. 108); at Neutson's resort (IV, 5) on July 21 (44. A); in the rock clearings (I, 2) on July 13 (G. 68); on the rock ridges on the McCargoe trail (II, 3) on July 25 (G. 147); in the clearing about the Light-house (I, 7) on July 8; and near the head of Rock Harbor (III, 6) on July 17 (G. 111). The species thus showed a decided preference for the open dry situations. Prof. H. Osborn writes concerning the specimens sent to him for determination: "These specimens agree closely with a variety of *rimosa* occurring at Ft. Bridger, Wyoming."

Concerning the habits of this species Osborn ('96, p. 196) states that in northwestern Iowa it occurs "on prairie land remote from timber, thus indicating a habit quite different from the other members of the genus." The occurrence of this species in the more or less open place upon Isle Royale is thus in harmony with its prairie habits and shows that these rock openings may contain not only forms of northern faunal affinities but also those from the western plains. The occurrence of these western species in open places in the northern forest region is analogous to the southern prairie species found in dry or sandy places in the south-eastern forests.

Jassideae.

Bathoscopus pruni Prov. This leaf hopper was taken from a rock pool upon a small island in Tobin Harbor (IV, 2) on July 19.

Coccidae.

Orthesia sp. This bark louse was taken July 19, at Scovill Point (IV, 1). "Undescribed so far as I can discover." H. Osborn.

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NEUROPTERA.

Myrmeleonidae.

Myrmeleon immaculatus DeG. Ant-lion. An apparently full grown ant-lion was taken on one of the bare burned over ridges on the McCargoe Trail (II, 3), on July 25. None of the adult insects were seen and this was the only specimen and funnel observed.

Geographic Range. Maine; Keene, N. H.; Isle Royale, Mich.; Illinois; Washington, D. C.; North Carolina; Texas; Colo.; Oregon; Calif. cf. Psyche, 9, p. 95.

ODONATA—DRAGONFLIES.

The Dragonfly collection secured by the party is an interesting one in several respects as will be seen by reference to the geographic distribution of the various species. Most of the specimens were collected by H. A. Gleason; the writer and other members of the party also secured some. We are indebted to Mr. E. B. Williamson of Bluffton, Indiana, for the determination of the series.

Agrionidae.

Lestes unguiculatus Hag. A single female, apparently of this species was found in the clearing at Neutson's resort (IV, 5) July 21.

Geographic Range. Nova Scotia; Quebec; Maine; Mass.; Rhode Island; New York; Penn.; New Jersey; Ohio; Indiana; Tenn.; Illinois; Iowa; Missouri; Wyoming; Montana; California; Corunna, Ann Arbor, Porcupine Mts., Mich.

Nehalennia irene Hag. Two males of this species were found in or near a tamarack-spruce-sphagnum swamp (I, 6) on July 10. This is a

swamp-land species which usually flies slowly among the low vegetation.

Geographic Range. Ontario; Maine; New Hampshire; Mass.; New Jersey; Florida; New York; Penn.; Ohio; Indiana; Illinois; Iowa; Wisconsin; South Dakota; Ann Arbor (Kavanaugh Lake, VII, 3, '03), Porcupine Mts., Mich.

Enallagma exsulans Hag. One male was taken flying over the water near the boat landing at Lake Desor (VII, '04) on August 20.

Geographic Range. Ontario; Maine; New York; Penn.; Maryland; District of Columbia; Virginia; Ohio; Indiana; Illinois; Missouri; Texas; Corunna, Huron River, near Portage Lake, Aug. 31, '03, Washtenaw Co., Kavanaugh Lake, July 10, '03, Chelsea, Mich.

Enallagma hageni Walsh. This species was quite abundant about the sedge margin of Sumner Lake (III, 5) where eight males were taken between July 24 and 29. Three other males were taken on August 16 in the cassandra and sedge zone about a pond near Siskowit Bay (V, 11).

Geographic Range. Newfoundland; Quebec; Ontario; Maine; New Hampshire; Mass.; New York; Delaware; Maryland; Ohio; Indiana; Illinois; Iowa; Missouri; Wisconsin; South Dakota; (July 10, '03, Kavanaugh Lake) Chelsea, Porcupine Mts., Mich.

Gomphidae.

Ophiogomphus colubrinus Selys. One female was taken, August 7, flying low, at the outlet of Siskowit Lake (V, 9). This stream falls rapidly providing a rapid water habitat which furnishes favorable conditions for most Gomphids. The streams on the island are small and flow through much swamp land so that there is but a slight development of the rapid water habitat.

Geographic Range. Hudson Bay; Quebec; Maine; New Hampshire.

Aeschnidae.

Anax junius Drury. Nymphs only were taken. Cf. Needham report.

Geographic Range. Central America northward to Newfoundland and Alaska; Bermudas; West Indies; Hawaiian Islands; Tahati; China; Kamtschatka. This is a very extensive range, quite exceptional among Dragonflies, and perhaps only surpassed by the cosmopolitan *Pantala flavescens.*

Aeschna sitchensis Hag. One female was taken along the road through the hardwoods on the Desor trail (III, '04) on August 21. (Psyche, 1890, p. 353).

Geographic Range. Sitka, Alaska; Saskatchewan; Newfoundland; (Williamson, '06, p. 135); Pequaming, Michigan, Calvert, Ent. News. 15, p. 288.

Aeschna species? The remaining Aeschnids cannot be satisfactorily determined at present. A male was taken in the sedge and cassandra zone bordering a pond (V, 11) on August 16. A male, which had been patrolling a small stream flowing from a tamarack swamp (V, 5), was taken on August 8. A teneral female was taken July 13 on a rock ridge (I, 2) and in the clearing about the camp on Siskowit Bay (V, 3) (231); one male was taken August 15, and a female on August 12. Eight males were taken at Sumner Lake (III, 5) between July 26 and 29. A female was taken in a rock clearing near the light-house (I, 2) on July 13 (69).

Three nymphs skins were found at the margin of the sedge zone of Sumner Lake (III, 5). Compare Walker, '08, who has examined the Isle Royale specimens.

Cordulidae.

Tetragoneuria spinigera Selys. One specimen was captured in a low rock opening at the shore, near the head of Rock Harbor (near III, 2) on July 14; and a female was taken floating upon the water in the west cove at the head of the Harbor (III, 6). The third specimen, a female, was secured from a rock ridge near the head of the Harbor near III, 2, July 21. (132.)

Geographic Range. Maine; New Hampshire; Mass.; Georgia; Detroit, Mich.; Vancouver Island.

Cordulia shurtleffi Scudd=*aenca* L. Three specimens, two males and one female, were taken at the edge of the water in the sedge zone on the north side of Sumner Lake (III, 5) on July 29. (184, 78A.)

Geographic Range. Nova Scotia; Newfoundland; Ontario; Maine; New Hampshire; Penn.; Saskatchewan; Fort Resolution; Mackenzie; British Columbia; Alaska; Northern Asia; Europe; Algeria.

Somatochlora elongata minor Calvert. Only one male of this interesting species was found, it was flying about the mouth of a small stream at the head of Rock Harbor (III, 3) (165) on July 26. Cf. Calvert, Ent. News 1898, 9, p. 87.

Geographic Range. Quebec; Maine; New Hampshire; Michigan; Wyoming.

Libellulidae.

Celithemis eponina Hagen. Nymphs only taken. Cf. Needham report.

Geographic Range. United States east of the Rocky Mountains and southern Canada (Ontario).

Leucorhinia hudsonica Selys. Three females were taken in the sedge zone of a tamarack swamp (V, 5) on August 8. (96A). *Sympetrum obtrusum* occurred abundantly in the same locality.

Geographic Range. Quebec; Nova Scotia; New Brunswick; Newfoundland; Maine; New Hampshire; Mass.; Lake Winnipeg; Saskatchewan River; Fort Resolution, Mackenzie; Alberta; British Columbia; Alaska.

Leucorhinia proxima Calvert. About the margins of Sumner Lake (III, 5) these dragonflies were very abundant on July 18, 24, and 29, and 19 males and 5 females were taken in the sedge zone. About the lake this zone was quite extensive, as shown by the photographs. Most of our collecting of insects was done at the northeast end where, with the aid of boots, an excellent swamp collecting ground was found. The ground was very wet, and spongy, and treacherous in places, on account of these soft spots. This species also occurred abundantly about the margins of a similar pond near Siskowit Bay (V, 11), where it was associated with *Enallagma hageni*, *Aeschna* and *Sympetrum rubicundulum obtrusum*. There is an interesting correlation between the geographic range of this genus and of its close ally *Sympetrum* (both are primarily boreal, throughout both hemispheres) and the geographic development of those habitat conditions which they prefer.

Geographic Range. Nova Scotia; Ontario; Maine; New Hampshire; Mass.; Quebec; Vancouver Island; Kalso, British Columbia; Washington.

Leucorhinia intacta Hagen. Nymphs only taken. Cf. Needham report.

Geographic Range. Nova Scotia; Maine; New Hampshire; Massachusetts; New York; New Jersey; Penn.; Ohio; Michigan; Ontario; Indiana; Illinois; Wisconsin; Iowa; South Dakota; Nevada; Washington.

Sympetrum rubicundulum obtrusum (Hag.). In the open area about the camp on Siskowit Bay (V, 3) this species was very abundant. Eight males and eight females were collected on August 11 and 12. A male was also taken near the head of Siskowit Bay (VIII, '04) on August 13; and 3 males and 1 female were taken in the sedge zone of a tamarack swamp (V, 5) on August 8. The number of specimens taken is not a fair index of the abundance of this species as an effort was made only to secure representative forms. The open areas where the heath and juniper-cladonia plant society were the representative types of vegetation, seemed to afford feeding grounds for this species and they were very abundant in such places. It is in just such situations that the small forms of insect life are most abundantly seen on the wing.

Geographic Range. Nova Scotia; Ontario; Maine; New Hampshire; Mass.; Penn.; New Jersey; North Carolina; New York; Ohio; Indiana; Illinois; Wisconsin; Colorado; British Columbia; Washington; Corunna, Ann Arbor, Porcupine Mts., Isle Royale, Mich.

Libellula quadrimaculata L. A single male specimen represents this species. It was collected about the Light-house clearing (I, 7) on July 25. (153).

Geographic Range. Newfoundland; Nova Scotia; Ontario; Maine; New Hampshire; Mass.; New York; Quebec; New Jersey; Penn.; Ohio; Indiana; Illinois; Wisconsin; Wyoming; Montana; Idaho; Utah; Washington; British Columbia; Alaska; Northern and Central Asia; Northern Europe; Asia Minor; Corunna, Isle Royale, Mich.

Geographic Notes. Attention is called to the geographic range of the following species:

1. *Ophiogomphus colubrinus.* Hudson Bay; Quebec; Maine and New Hampshire.
2 *Aeschna sitchensis.* Sitka, Alaska; Saskatchewan; Michigan; Newfoundland.
3. *Somat. e. minor.* Maine; Quebec; New Hampshire; Wyoming.
4. *Cordulia schurtleffi* (=*aenea* L.) Newfoundland; Nova Scotia; New Hampshire; Mackenzie; British Columbia and Alaska; Northern Asia; Europe; Algeria.
5. *Tetra. spinigera.* Maine; Georgia; Mich.; Vancouver Island.
6. *Leucor. hudsonica.* Newfoundland; Nova Scotia; west to Winnipeg, the Mackenzie basin and British Columbia.
7. *Libel. quadrimaculata.* Newfoundland and Alaska; New Jersey; northwestward to Wyoming; Washington; British Columbia; Northern Europe; Asia.

From the above it is seen that seven of the Isle Royale dragonflies are decidedly representative of the region from Labrador to Alaska (and

more especially of the eastern part of this area), largely north of the U. S. boundary. There is also a marked transcontinental tendency. As these forms do not now occur abundantly even in the mountain regions of the west, it is likely that many have spread northwest in post-Glacial times with the Northeastern Biota, rather than from the regions south of the western glaciated area with its relatively arid climate.

Of these seven species the following four: *Cordulia aenea* (*C. schurtloffi*), *Leucorhinia hudsonica* and *Libellula quadrimaculata*, are Asiatic (Northern) and European—thus circumpolar. As to the geographic origin of these forms very little can be said, as the taxonomic relations of the Odonata, from a geographic and ecologic standpoint, has never been attempted. Attention, however, should be called to the fact that so far as known, these are all forms that frequent quiet waters.

There is an interesting correlation between the geographic range of the genera *Leucorhinia* and *Sympetrum* and the geographic development of the habitat conditions which they frequent. Both are circumpolar in the subarctic region. This same area (especially in America) also furnishes the greatest almost continuous tract of lake, pond and swamp conditions found upon the earth. In North America at least, the base leveling of the region, its imperfect drainage due to glaciation, and its cool climate are the important or dominant factors in the production of this extensive area of favorable habitats for these genera. It is very probable that many animals, dependent upon such conditions, will show a similar correlation.

The powerful flight of the larger species suggests that the present distribution of the above listed circumpolar species may have taken place under conditions similar to those which exist today. Thus the habitat preferences and the present geographic distribution of the species all suggest a faunal interchange via Alaska and Siberia. Such a change might have occurred during Glacial, inter-Glacial or post-Glacial times, but at present we have no criteria or evidence by which to determine such relations.

The migratory habits of certain species of dragonflies also has a direct bearing upon the extensive range of certain species. One Isle Royale species, *Libellula quadrimaculata*, has long been known to migrate (cf. Dragon Flies and Mosquitoes, 1890, p. 161).

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LEPIDOPTERA.

Check List.

1. *Carneades bostoniensis* Grt.
2. *Hemaris definis* Bdv.
3. *Hemaris thysbe* Fabr.
4. *Papilio glaucus turnus* L.
5. *Colias philodice* Godt.
6. *Argynnis cypris* Edw.
7. *Argynnis atlantis* Edw.
8. *Brenthis myrina* Cramer.
9. *Brenthis bellona* Fabr.
10. *Phyciodes tharos* Dru.

11. *Eugonia j-album* Bd.—Lec.
12. *Euvanessa antiopa* L.
13. *Aglais milberti* Godt.
14. *Vanessa atalanta* L.
15. *Vanessa hunteri* Fabr.
16. *Vanessa cardui* L.
17. *Basilarchia arthemis* Dru.
18. *Anosia plexippus* L.
19. *Epidemia dorcus* Kby.
20. *Epidemia epixanthe* Bd.—Lec.
21. *Cupido saepiolus* Bd.
22. *Amblyscirtes vialis* Edw.

Noctuidae.

Carneades bostoniensis Grt. A moth of this species was taken about camp on Siskowit Bay (V, 3) on August 9 (G. 222).

Geographic Range. "Middle, Eastern and Northern States", Massachusetts; New York; Michigan; Canada.

Sphingidae.

Hemaris definis Bdv. One specimen taken in the clearing about the camp (I, 7) on July 8 (G. 36).

Geographic Range. "Canada, Hudson Bay Territory, Maine to Georgia, westward to Missouri, Iowa" (Smith). Michigan.

Hemaris thysbe Fabr. One specimen in the open about the camp on Siskowit Bay (V, 3) on August 3 (G. 195). Food plant *Viburnum.*

Geographic Range. "Labrador, Canada; southward to Florida; westward to the Mississippi" (Smith); Michigan.

Papilionidae.

Papilio glaucus turnus L. Turnus Butterfly. Nine specimens were taken along the beaches (I, 1) on July 9, one in the clearing about the Light-house (I, 7) on July 8, and another on July 14, in a rock clearing near the head of Rock Harbor (near III, 3). The Isle Royale specimens of this species, when compared with specimens from Ann Arbor, are much dwarfed; the right fore wing of three specimens measuring 41, 42 and 47 mm. respectively. Most of the specimens secured were old worn males. This species is known to become dwarfed both in the far north (Alaska) and upon mountains (White Mountains, N. H.). A number of animals show this dwarfing tendency to the northward when they are of southern origin. Scudder, '99, p. 158.

Geographic Range. Newfoundland into Florida; U. S. generally; California into Alaska except in southern British Columbia. This is a species of southern origin; its relatives are South American.

Pieridae.

Colias philodice Godt. Clouded Sulphur Butterfly. This species was not taken in 1905 but is recorded by Ruthven ('06, p. 103) from the south end of the island.

Geographic Range. Anticosti, Quebec; Ontario; Newfoundland; Maine; New Hampshire; Mass.; New York; Penn.; West Virginia; New Jersey; Florida; Ohio; Illinois; Indiana; Kansas; Nebraska; Texas; Dakota; Iowa; Colorado. Scudder, '99, p. 24.

Nymphalidae.

Argynnis cypris Edw. One specimen was taken on the burned over ridges (II, 3) on July 25 (G. 147); another August 14 on *Solidago,* in an open area near the beach (V, 2), (A. 115). Determined by Dr. J. Fletcher and Dr. Wm. Barnes.

Geographic Range. A western Rocky Mountain species.

Argynnis atlantis Edw. Atlantis Butterfly. One specimen was taken on the rock ridge near the head of Rock Harbor (III) on July 21 (G. 132); two in the clearing at Neutson's resort (V, 5) on July 21 (G. 121); one from the burned over rock ridges on the McCargoe trail (III, 3) on July 25 (G. 146, 147); and five from the clearing about the camp on Siskowit Bay (V, 3) on August 4, 9, 10 and 16.

Scudder says: "The favorite resorts of this butterfly are grassy fields skirting the mountain streams, and it differs slightly from other species of the genus, preferring sunny woodland nooks to open country." Scudder, '99, p. 213.

Geographic Range. Labrador; Newfoundland; Nova Scotia; Rupert House, Quebec; Ontario; White Mts., N. H.; Catskill and Adirondack Mts., N. Y.; Indiana; Michigan; Iowa; Wisconsin; Lake Winnipeg; Colorado; Mackenzie and Hudson Bay.

Brenthis myrina Cram. Myrina Butterfly. One specimen was taken at Sumner Lake (III, 5) on July 18 (G. 120); a second one upon a *Solidago* flower near a small stream flowing from the tamarack swamps (V, 5) on August 8 (G. 97). Scudder remarks that this species "frequents low, moist meadows and roadsides in their vicinity." Scudder, '99, p. 317.

Geographic Range. Nova Scotia and New England; south on the Mountains to Maryland, Virginia and North Carolina; Indiana; northern Illinois; Wisconsin; Iowa; Colorado; Utah; Montana; Alberta; British Columbia; Sitka, Alaska; Saskatchewan; Nipigon, Ontario; Hudson Bay. Has a near relative in Asia, *B. amphisaphe.*

Brenthis bellona Fabr. Bellona Butterfly. One specimen, no data. Scudder, '99, p. 311.

Geographic Range. Quebec; New England; Ontario; Penn.; New Jersey; Virginia; northern Ohio; Indiana; Alberta; Colorado; Great Slave Lake; Lake Winnipeg and Hudson Bay.

Phyciodes tharos Dru. Tharos Butterfly. One specimen was taken on the beach (I, 1) on July 10 (G. 209). Scudder, '99, p. 121.

Geographic Range. Southern Labrador into Florida; west to Texas, Mexico and the Sierra Nevada; British Columbia; Alberta; Saskatchewan; Mackenzie River and Hudson Bay.

Eugonia J-album Bd.—Lec. White J. Butterfly. Two specimens were taken August 23 and 24 in the clearing at Washington Harbor (I, '04) and at the Siskowit Camp (V, 3) on August 16. Scudder, '99, p. 7. This butterfly, according to Scudder, frequents "high open wood-

land, and on hilly roadsides in the vicinity of woods." Perhaps migrates. The butterfly hibernates. cf. Scudder, '97, pp. 139-144.

Geographic Range. No. Labrador; Nova Scotia; Ontario; mountains of Penn.; Indiana; Wisconsin; British Columbia; Alaska. Closely related to the European *E. van-album.* Probably of Asiatic origin.

Euvanessa antiopa L. Antiopa Butterfly. Not secured in 1905 but recorded by Ruthven ('06, p. 103) from the south end of the island. This is a wide ranging species from Gautamala and Mexico northward over most of the United States and southern Canada; Alberta; British Columbia; Alaska; northern Asia and Europe. Scudder, '99, p. 1. This species is probably of Asiatic origin. The butterfly hibernates.

Aglais milberti Godt. Milbert's Butterfly. One specimen was taken in the clearing at the Light-house on Rock Harbor (I, 7), (G. 36). Scudder, '99, p. 330. Butterfly hibernates.

Geographic Range. Labrador; Newfoundland; New Brunswick; Ontario; Nova Scotia; New Hampshire; New York; northern Ohio; Indiana; Montana; Colorado; Arizona and New Mexico, on the mountains; Alberta; British Columbia south to central California; Great Slave Lake; Mackenzie; Lake Athabasca; Hudson Bay. A distinctly northern and mountain species.

Vanessa atalanta L. Red Admiral. Two specimens were taken in the light-house clearing (I, 7), (G. 45). This butterfly hibernates. Scudder, '99, p. 79.

Geographic Range. Southern Labrador; Newfoundland; Hudson Bay; Alberta; British Columbia; of general distribution over United States and extending southward on the mountains into Guatamala; Europe; Northern Asia and Africa. The extensive southward distribution on the mountains is worthy of note. This species probably originated in Asia.

Vanessa hunteri Fabr. Hunter's Butterfly. A much worn specimen was taken July 19, on the beach (I, 1), (G. 29), and on July 21 in the clearing at Neutson's resort (IV, 5), (G. 121). Scudder, '99, p. 114. Butterfly hibernates. Larva feeds on the Pearly Everlasting, *Anophalis margaritacea* B. & H. (Dr. J. Fletcher), but the plant was not found upon Isle Royale.

Geographic Range. Nova Scotia; Quebec; Ontario; Minn.; British Columbia; United States generally; Mexico; Central America, and along the Andes perhaps even to Patagonia; Antilles; Canary Isles. This species, like the preceding, has an extensive southern distribution along the mountains. Of North American origin.

Vanessa cardui L. Thistle Butterfly. Four specimens were taken July 21, in the clearing about Neutson's resort (IV, 5), (G. 121); two more upon the beach (I, 1) on July 10; a wing was found among the drift on the beach (I, 1); several from the clearing at the Light-house (I, 7) on July 7, 10 and 22 (G. 26, 45, 104, 133); one in the clearing about the camp on Siskowit Bay (V, 3) on August 7 (G. 212) and in the cassandra and sedge zone about a pond on Siskowit Bay (V, 11) on August 16. Scudder, '99, p. 106. This butterfly hibernates. This species, with *Argynnis atlantis* and *Basilachia arthemis,* were the most abundant butterflies upon the island.

Geographic Range.—This butterfly has the most extensive range of

any known species. "With the exception of the Arctic regions and South America, it is distributed over the entire extent of every continent." (Scudder). This species is very abundant in Southern Europe; continually invades northern Europe but cannot establish itself. It swarms in immense numbers both in Europe and in America (Calif.). Fletcher, '02, p. 56; Farnham, '95, p. 150; Scudder, '76. This species is probably of North American origin. Its inability to withstand, even in the adult stage, the winters of northern Europe and northern North America, and its powers of flight suggests that this species, which is probably of southeastern North American origin, reached the old world not only by way of the north but also across the Atlantic Ocean. Specimens have been taken at sea 200 miles from the Cape Verde Islands in the Atlantic.

Basilarchia arthemis Dru. Arthemis Butterfly. This butterfly was very abundant along the beaches, where they were frequently taken on Conglomerate Bay (near I, 5) and where two specimens were taken on July 10; five other specimens were taken along the beaches on July 19 (G. 29) and one on July 11 and 17 respectively (G. 47, 107); also one specimen in the Light-house clearing (I, 7) on July 8, 10, 24, 26, and two on July 17. A single specimen was taken along the path at the outlet of Siskowit Lake (V, 9) on August 7 (G. 215). This was a burned over area and was relatively open and especially so on the rock exposures. Three specimens were taken in the clearing about the camp on Siskowit Bay (V, 3) on August 9 (G. 222). It was also abundant in rock clearings near the head of Rock Harbor (near III, 3) on July 14 (G. 97).

This purple black butterfly with its oblique white band is a conspicuous form along the beach, on the rock openings, and in the clearings and burnings. Scudder, '99, p. 225.

Geographic Range. Newfoundland; Nova Scotia; Quebec; Ontario; northern New England; New Hampshire; northern and western Mass.; Catskill and Adirondack Mts., N. Y.; mountains of Penn.; southern Mich.; southern Wisconsin; northern Indiana; Minnesota; Alberta; British Columbia; Fort Simpson, Mackenzie. Of North American origin. cf. Field, '04, p. 1.

Anosia plexippus L. Milkweed Butterfly. Two dead specimens and one yet alive were found upon the beach at the head of a small cove south of the Light-house (I, 1) on July 6 (G. 19). On the following day about a half dozen dead specimens were also found under similar conditions. This drift must have been cast up several days previously, as was indicated by its stage of decay. A single bright colored fresh looking specimen was taken near the head of Siskowit Bay (VIII, '04) on August 13, and is in striking contrast to the faded specimens preserved from the shore drift. Scudder, '99, p. 95.

The food plant of the caterpillar is milkweed, one species of which, *Asclepias incarnata* L., was found along Washington River (II, '04).

This species is not, in all probability, a permanent resident of the island, as it cannot endure the winters of eastern Canada. Scudder ('93, p. 52) has expressed the opinion that this species cannot survive the winter north of the Gulf States and that those individuals found further north reach there each year as migrants from the south, or the

immediate descendants of such migrants. It is well known that these butterflies congregate in vast flocks in the fall and migrate, some think to the south (like birds), others that they wander about aimlessly until killed by the approaching winter (Tutt, '02, p. 127). This wandering tendency, however, would tend to scatter them as they died off slowly by exhaustion. While it seems incredible to think of a southerly migratory instinct, yet the meteorological conditions developing in the far north might give a southerly direction to the wandering movements.

The occurrence of specimens in the shore drift is of interest in connection with the wandering habit of this butterfly. Specimens have been picked up on the beaches of Lake Michigan (Needham, '00, p. 6); Lake Erie (Moffat, '01, p. 48); and Lake Ontario (Bowles, Can. Ent. Vol. 12, p. 134; and they have been observed flying over Lake Erie. Such facts as above cited suggest that this member of the Isle Royale fauna is restocked each year by migrants, which are probably more likely to come from the southern rather than the northern shore of Lake Superior. If Scudder's opinion is correct, an annual extension of range from the Gulf States to Isle Royale—over 1,200 miles—certainly shows remarkable powers of dispersal.

Geographic Range.—This species has a very extensive range in this hemisphere from northern Patagonia in South America, northward through the tropics, West Indies, over most of the United States and southern Canada to British Columbia, Hudson Bay and Lake Athabaska. Through man's influence this species has become almost world-wide in its range. It has been recorded from the south Pacific 500 miles from land (Tutt, '01, p. 40). Originally it was of American origin.

Lycaenidae.

Epidemia dorcas Kby. A single specimen of this was taken on August 16 in the Cassandra and sedge zone of an open bog (V, 11), (A. 136). Determined by Dr. James Fletcher.

Geographic Range.—Michigan (Isle Royale); Nipigon, Ontario; Manitoba; Saskatchewan; Athabasca; Alaska.

Epidemia epixanthe Bd.—Lec. Exipanthe Butterfly. Four specimens were taken on the sedge zone on the north shore of Sumner Lake (III, 5) on July 29.

This is a swamp species about which Fiske ('01, p. 50) writes: "It confines itself closely in its journeyings to the swamp or bog in which its early stages are passed, and rarely indeed ventures upon higher ground. It loves best of all an open, mossy morass, such as are found scattered throughout New England, usually surrounding some small pond caught in a hollow between the hills, and formed by the moss and subaquatic plants which, constantly encroaching upon the water, are bound in time to cover it over."

Geographic Range. Newfoundland; Quebec; Ontario; Maine; New Hampshire; northern Indiana; Iowa; Kansas and Nebraska.

Cupido saepiolus Bd. Greenish Blue Butterfly. In all seven specimens of this interesting western species were taken; one about the camp at the Light-house (I, 7) on July 7, (G. 26); a second in the clearing on Benson Brook (II, 1) on July 25 (G. 148), and five speci-

mens in the clearing about Neutson's Resort (IV, 5) on July 21 (G. 121).

Geographic Range.—Michigan (Isle Royale only); Great Slave Lake; Mackenzie Basin; British Columbia; Montana; Colorado; Nevada; California. Cf. Elrod, '06, p. 136; Carey, '06, p. 451. Isle Royale is also the most eastern record for this species.

Hesperidae.

Amblyscirtes vialis Edw. Vialis Skipper. Three specimens of this skipper were taken on July 11 (G. 49), 22 (G. 133), and 28 (G. 179) in the clearing about the Light-house (I, 7).

Geographic Range. Quebec; Maine; New Hampshire to Florida and westward to Texas; Nevada; Alberta; Manitoba (Fletcher), and British Columbia.

Geographic Notes. After the preceeding geographic records had been secured, the following notes on the distribution of butterflies in Canada were received from Dr. James Fletcher, of Ottawa, Canada. His letter contains so many interesting features that I have thought it desirable, with Dr. Fletcher's consent, to publish it in full, supplementary to the data already given, rather than to scatter the records.

"In just running through your letter I see that I can answer it without turning up any records. The geographical range in Canada of the following butterflies is as follows: *Papilio glaucus turnus*—from the Atlantic to the prairie region, common; across the prairies into British Columbia, rather scarce, and not to my knowledge crossing the interior elevated plateau which is a semi-arid region. North of this in the mountains it reaches right to the Pacific Coast. South of the north part of Vancouver Island its place is taken by *Pap. eurymedon* and P. *rutulus arizonensis* as named by Mr. W. H. Edwards.

"*Colias philodice*—very abundant from the Atlantic to the Lake Superior region, where its place is taken by *C. eurytheme,* of which one form, the variety *eriphyle* resembles *philodice* very closely and although it is claimed that it is a form of *eurytheme* it resembles *philodice* so closely that it cannot always be separated unless the locality is known.

"*Argynnis atlantis*—this occurs in what we consider the typical form from the Atlantic coast to the Great Lakes. West of that the black markings are rather lighter and the color is brighter. In the Rocky Mountains I believe what we have been calling *electa* is merely a form of *atlantis.* That at any rate extends to the main chain of the Rockies, but I have never seen it further west than the Arrow Lakes.

"*Brenthis myrina* and *bellona*—from Atlantic Coast to the interior plateau of British Columbia.

"*P. tharos*—from the Atlantic Coast to British Columbia, running north to the coast, probably with the main chain of the Rockies. In Vancouver Island and the Fraser River Valley its place is taken by *P. pratensis* and the same areas are inhabited by *Brenthis epithore* in place of *bellona. Pratensis* however extends west into Manitoba.

"*Eugonia j-album, E. antiopa, A. milberti, V. atalanta* and *V. cardui* occur over the whole of our country from Atlantic to Pacific and from the southern border to the arctic regions.

"*V. hunteri* also occurs right to the coast but is very much rarer west of the Great Lakes than the other species mentioned. I have it from Nova Scotia and also took it on Vancouver Island.

"*Basilarchia arthemis* extends from the Atlantic coast to the Kootenai Lakes, when its place is taken by *B. lorquinii*. *Anosia plexippus* a migrant and may turn up at any place where *Asclepias* grows, but is much rarer in British Columbia.

"*Epidemia epixanthe*.—This is the only species I have some doubts about. There is no doubt that some of the records of *epixanthe* should be of the rare and little understood species *dorcas* which occurs in the Lake Superior region and into Manitoba. It is easily distinguished from *epixanthe* by its slightly larger size and the brilliant orange wash on the under surface. *Epixanthe* I have only actually taken myself in Ontario. *Dorcas* I have from Nepigon on Lake Superior the Bruce peninsula and from Manitoba. West of that the form, for it is hardly a variety, *florus* which is really only a dimorphic form of *helloides* occurs, and has I think, sometimes been recorded as *epixanthe*. The reference of *florus* to *dorcus* instead of *helloides* as a variety, which was done by Dr. Dyar, has in my opinion no reason in it at all.

"*Amblyscirtes vialis*.—This is nowhere very common but extends from Atlantic to the Pacific coast. I have specimens from Halifax, Nova Scotia and have taken it in Vancouver Island. It is more abundant perhaps in the Lake Superior region than any other where I have collected."

The butterfly fauna of Isle Royale may well be compared to that of the White Mountains of New Hampshire on account of the large number of species common to both localities (cf. Scudder, '97, pp. 71-87). Much the same resemblance holds for northern New England in general. So far as United States is concerned Isle Royale is the western outlier of the distinctly northeastern or Canadian biotic type. Perhaps the Black Hills will show similar affinities, but farther west a marked Rocky Mountain influence becomes apparent. It is of interest to note that six of the eighteen species hibernate as butterflies and another spreads each season into the region. This number includes the species which are of the most northern range and one (*V. cardui*) which is cosmopolitan. Four of the species, *E. j-album*, *P. cardui*, *B. arthemis* and *A. plexippus* are known to flock, or migrate. There can be but little doubt but that these characteristics are important factors in an understanding of their geographic range, and are probably adaptations which permit these species to maintain themselves in the region. Such adaptations may have originated in response to the environment or the possession of them have allowed the species to enter the region already adapted to it.

When the above listed species are grouped geographically they fall into the following classes:

1. Of general geographic range from Labrador, Newfoundland, northern New England, southward on the Adirondacks, Catskills and Appalachians, westward through northern Ohio, Indiana, Wisconsin to Alberta, and southward on the Rocky Mountains, British Columbia to Alaska.

1. *Argynnis atlantis.*
2. *Brenthis myrina.*
3. *Brenthis bellona.*
4. *Eugonia j-album.*
5. *Vanessa milberti.*
6. *Basilarchia arthemis.*

These forms may well be called members of the Canadian biota for they only extend a short distance southward on the lowlands of the United States, but reach much farther south at higher altitudes.

2. Much the same northern limit as group 1, but reaching much farther south of the above southern lowland limit.
    1. *Papilio glaucus turnus.*
    2. *Colias philodice.*
    3. *Phyciodes tharos.*
    4. *Euvanessa antiopa* (Asiatic).
    5. *Vanessa atalanta* (Asiatic).
    6. *Vanessa hunteri.*
    7. *Vanessa cardui* (cosmopolitan).
    8. *Anosia plexippus* (Nearly cosmopolitan).
    9. *Epidemia epixanthe.*
    10. *Amblyscirtes vialis.*
3. Species of distinctly Rocky Mountain or Rocky Mountain and Pacific coast distribution, and reaching their eastern limit in the Lake Superior region.
    1. *Epidemia dorcas.*
    2. *Cupido saepiolus.*
    3. *Argynnis cypris.*
4. Of very extensive geographic range, Asiatic or Cosmopolitan.
    1. *Pyrameis cardui.*
    2. *Anosia plexippus.*
    3. *Vanessa atalanta.*
    4. *Euvanessa antiopa.*

Probable geographic origin:

1. *Papilio glaucus turnus*, S. American.
2. *Colias philodice*, American.
3. *Argynnis atlanta*, Asiatic.
4. *Brenthis myrina*, Asiatic.
5. *Brenthis bellona*, Asiatic.
6. *Phyciodes tharos*, American.
7. *Eugonia j-album*, Asiatic.
8. *Euvanessa antiopa*, Asiatic.
9. *Vanessa milberti*, American.
10. *Vanessa atalanta*, Asiatic.
11. *Vanessa hunteri*, American.
12. *Vanessa cardui*, Amercian.
13. *Basilarchia arthemis*, American.
14. *Anosia plexippus*, So. American.
15. *Cupido saepiolus*, West No. Amer.
16. *Epidemia epixanthe*, Eastern U. S.
17. *Epidemia dorcas*, W. No. Amer.
18. *Amblyscirtes vialis*, No. Amer.

In discussing the geographic origin of the butterflies common to the old and new worlds, Scudder seldom attempts more than a hemispherical location. In discussing the origin of American faunae that are both boreal and Asiatic, it is well to recall that geologically speaking the American boreal and arctic are *largely of recent origin in the northern regions*. It is therefore not unlikely that many of these forms which it has been customary to consider boreal are in reality not so, but from high altitudes—from the North American Cordilleras or from the Himalayas, where high altitude and low temperature existed long before the Ice Age. With the development of an Ice Age, there was a great increase of this low temperature, lowland habitat and when once the glacial climate declined a vast area was open for invasion—an area of such great extent that we have become thoroughly accustomed to think the fauna has originated there. It has thus become customary to speak of them as of northern origin, in spite of the fact that we know that they are almost entirely post-Glacial migrants *from the south*.

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ANNOTATED LIST OF THE MOLLUSCA OF ISLE ROYALE, MICHIGAN.

BY BRYANT WALKER.

1. *Introduction.*

This list contains all the species of molluscs collected on Isle Royale, both in 1904 and 1905, and so represents the complete fauna so far as known. For the details as to the localities represented by the collection made in 1904, reference should be made to the Report of that expedition (pp. 96-99).

The collection made in 1905 was much larger than that of the preceding year, both in species and individuals. While eleven of the species collected in 1904 were not found in 1905, no less than forty-two additional species were obtained, making the total number of species now known from the island seventy-two. The species added in 1905 are indicated by an * on the list. In compiling the completed list, it has been deemed of sufficient interest to add both the general range of each species and its distribution so far as known in the state of Michigan.

2. *Faunal Affinities.*

The molluscan fauna of Isle Royale becomes of additional interest when considered in conection with Dr. W. H. Dall's recent work on the "Land and Fresh Water Mollusks of Alaska and Adjoining Regions," (Harriman Alaska Expedition, Vol. XIII, 1905), which is a complete digest of our present knowledge of the land and fresh water mollusca of North America north of latitude 49° North, and practically of our entire boreal fauna. So far as available, the general range of the species given in that work has been followed in this list as being the most "up-to-date" attainable.

Of the seventy-two species recognized from Isle Royale, forty-nine are included by Dr. Dall in his list of boreal species.

The remaining twenty-three species not cited by him are:

Strobilops virgo (Pils.)
Vertigo tridentata Wolf.
Euconulus chersinus polygyratus Pils.
Zonitoides exigua (Stimp.)
Agriolimax campestris (Say).
Pallifera hemphilli (W. G. Binn.).
Pallifera dorsalis (Binn.).
Lymnæa pilsbryana Walker.
Physa sayii Tapp.
Physa aplectoides Sterki.
Ancylus sp?
Amnicola lustrica Say.
Musculium securis Prime.

Pisidium affine Sterki.
Pisidium sargenti Sterki.
Pisidium roperi Sterki.
Pisidium subrotundum Sterki
Pisidium splendidulum Sterki.
Pisidium pauperculum Sterki.
Pisidium medianum Sterki.
Pisidium punctatum simplex Sterki.

Of these *Lynnœa pilsbryana* is, so far as yet known, peculiar to Isle Royale. The remainder have, as a rule, a general distribution all over the state. *Strobilops virgo* and *Zonitoides exigua*, however, are characteristic boreal species and are apparently rarely found south of the Saginaw-Grand Valley. While, of course, it is possible that Isle Royale marks the northern limit of the range of these species, in view of the fact that nearly all of them are known to range through the Upper Peninsula and that practically nothing is known of the fauna of the north shore of Lake Superior, the probability is that most of them range further north and should be included in the boreal fauna of North America. While the Isle Royale fauna is thus to be considered purely boreal in its character, it must be understood that it is not in any material respect different from that of the Upper Peninsula and of the northern part of the Lower. The occurrence of such species as *Vallonia costata*, *Vertigo tridentata* and *Physa aplectoides* must be considered rather as evidence that these forms have been overlooked in the region immediately south rather than that they are restricted to Isle Royale. And the existence of *Lymnœa pilsbryana* and the peculiar forms of *Lymnœa stagnalis, Planorbis bicarinatus* and *P. campanulatus,* if ultimately found to be confined to the island, should rather be ascribed to long isolation under peculiar local conditions than as indicating any essential difference from the fauna of the surrounding region.

Considering the fauna of the Upper Peninsula and Isle Royale as a whole, it will be found to include two elements. The first and larger one consists of species having a general range through the northern United States and southern portion of Canada. Just how far to the north most of them range is as yet undetermined. These species, although found in the boreal region, cannot be properly said to be distinctly boreal species. Accompanying these species of general distribution, is a smaller element of purely boreal species, which are characteristic of the northern region and whose range to the south is as a rule quite restricted. This purely boreal element is represented on Isle Royale by the following species:

1. *Acanthinula harpa* (Say).
2. *Vitrina limpida* Gould.
3. *Vitrea binneyana* (Mse.).
4. *Zonitoides exigua* (Stimp.).
5. *Pyramidula asteriscus* (Mse.).
6. *Lymnœa megasoma* Say.
7. *Lymnœa emarginata* Say.
8. *Lymnœa pilsbryana* Walker.

So far as the land species of Isle Royale are concerned, there are but few of special interest, most of them being of general distribution

in the Upper Peninsula. The occurrence of *Polygyra albolabris* (which was not found in 1904) in abundance causes a feeling of surprise that *Polygra fraterna* (*monodon* auct.) was not found. In Michigan, its range is coincident with that of *albolabris* and, according to Dall, it is found as far north as James Bay, Hudson Bay.

All the specimens collected of *Pyramidula cronkhitei* were of the *anthonyi* form as in 1904.

Among the fluviatile species, however, several forms either previously undiscovered or new to the fauna of the state were found and some interesting facts in regard to their distribution were developed. The division of *Lymnæa stagnalis* into three very distinct forms coincident with the character of their habitat is very striking and specially noteworthy.

The fact that all the larger species of *Lymnæidae* from Siskowit Lake: *Lymnæa stagnalis, Planorbis bicarinatus* and *Planorbis campanulatus,* are well marked varieties peculiar to that lake, is very significant and points to some specially favorable environmental conditions, which apparently are not present to affect the facies of these species on other parts of the island. What these are, if not already determined, would be an interesting subject for future investigation.

The acquisition of the additional material, which has enabled the specific distinctness of *Lymnæa pilsbryana* to be determined, is a matter of congratulation.

The occurrence of the beautiful little *Physa aplectoides* adds a new species to the fauna of the state and affords another instance of apparently anomalous distribution, which so frequently puzzles the student. Originally described from Ohio, it has hitherto escaped attention in southern Michigan, and its discovery on Isle Royale was wholly unexpected. The remarkable form of *Planorbis bicarinatus* from Siskowit Lake was one of the most interesting novelties discovered by the expedition and is a noteworthy addition to the fauna of the state.

"All the *Pisidia,* except *Pisidium idahoense* and *Pisidium sargenti,* are represented by small, and, as it seems, characteristically northern forms, slight and generally of light or pale color. Some are not very characteristic and apparently little different from each other and were rather difficult to work up." (Sterki.)

The writer again acknowledges his indebtedness to Dr. V. Sterki for the identification of the *Sphæria* and *Pisidia* and to Dr. H. A. Pilsbry for the determination of the slugs. Dr. H. A. Gleason, who collected most of the specimens, and Mr. Chas. C. Adams have kindly interpolated the details as regards the local habitats and distribution of the different species. The field numbers by Mr. C. C. Adams are indicated by the letter A; all others are Dr. Gleason's, except a few lots collected by Mr. N. A. Wood.

Detroit, April 1, 1909.

3. *Annotated List.*

1.* *Polygyra albolabris* (Say).

Range: "Eastern United States, from Georgia and Arkansas to the Saskatchewan." (Dall).

Michigan: Generally distributed.

Distribution on Isle Royale: Station I, Sub. 1, Lake and Bay Beaches, Numbers 19, 32, 50; I, 5, Jack Pine Ridges, Nos. 19 A, 23, 33, 81, 187; I, 7, Light-house Clearing, Nos. 34, 42; II, 1, Ransom Clearing, No. 150; II, 2, Tamarack Swamp, No. 113; II, 3, Rock Ridge Clearing, Nos. 51, 145; III, 4, Trail to Sumner Lake, Nos. 88, 93, 138, 174; III, 5, Sumner Lake, No. 120; III, 6, Southwest Coves, Rock Harbor, No. 91; IV, 5, Neutson's Resort, No. 121; IV, 8, Trail to Greenstone Range, No. 128; V, 2, Heath Zone and Beach, Nos. 101 A, 107 A; V, 3, Rock Clearing at Camp, No. 233; VIII, '04, Upper End of Siskowit Bay, No. 232.

A "dead" shell was found in driftwood cast upon the beach at the head of Tonkin Bay (No. 19) and (No. 32) in a small creek at the head of Conglomerate Bay. The animal was dead but the body was still within the shell. In both of these numbers the shells were beyond their normal habitat.

Live examples (No. 50) were seldom seen but the abundance of the dead ones upon the rock ridges and open *Cladonia* clearings make it apparent that they are abundant here. Numbers, 23, 33, 81, 187, 51, 145, 88, 93, 138, 174, 128, 101 A, 107 A, 232 and 233 were all taken from that association. Thence they wander in small numbers to the moister places, such as the light-house clearing (Nos. 34 and 42), Ransom Clearing (No. 150), or even in the tamarack swamps (No. 113).

Although not found at all in 1904, this species was collected in 1905 in considerable numbers, which show a wide variation both in size and in the thickness of the shells. The 124 mature specimens collected varied in height from 14 to 21.5 *mm.*, and in width from 21.75 to 30.75 *mm.* The average being 17 by 25.86 *mm.* The accompanying diagrams, 61-62, show the variation in height and greater diameter.

A series of 42 from all parts of the Upper Peninsula vary in height from 14 to 20 *mm.*, and in width from 22, 75 to 30 *mm.*, with an average of 17.20 by 26.28 *mm.* While a series of 183 from all parts of the Lower Peninsula vary in height from 12 to 24.25 *mm.*, and in width from 18.75 to 34.25 *mm.*, with an average of 18.10 by 27.11 *mm.*

It would appear from these series that the average Isle Royale shell is slightly smaller than the average specimen from the Upper Peninsula, and considerably smaller than the average Lower Peninsula example. The range of variation in the Isle Royale series is somewhat greater than in the Upper Peninsula series, but much less than in that from the Lower Peninsula.

2. *Acanthinula harpa* (Say).

Range: "Northwestern Scandinavia, Northeastern America, British America near Hudson Bay, Southeastern Alaska and the easternmost margin of Siberia." (Dall.)

Michigan: Petoskey and Charlevoix in the Lower Peninsula, and Ontonagon County and Isle Royale in the Upper.

Isle Royale: I, 5, Jack Pine Ridges, No. 19 A; II, 1, Ransom Clearing, No. 150; V, 2, Heath Zone and Beach near Siskowit Bay, Nos. 118 A, 129 A, 130 A; V, 4, Trail through Balsam-Birch Forest, No. 236.

Number 150 was collected under logs resting on the ground in an open clearing near the lake; No. 236 was in leaf mold in the dense

shade of the balsam forest; No. 15 A was taken from under a stone; and No. 118 A, 129 A, 130 A from under mats of *Cladonia.*

3.* *Strobilops virgo* (Pils.).

Range: "Canada to Northern Alabama, and west to Minnesota and Kansas." (Pilsbry).

Michigan: Upper Peninsula and northern counties of the Lower.

Isle Royale: I, 5, Jack Pine Ridge, No. 81; V, 2, Heath Zone and Beach near Siskowit Bay, Nos. 129 A, 130 A; III, '04, Desor Trail, No. 142 A.

In damp soil (No. 81) under loose rocks at a depth of 2-6 inches; No. 129 A and No. 130 A from under *Cladonia;* and No. 142 A from leaf mould and rotten logs in the maple forest.

4.* *Bifidaria tappaniana* (C. B. Adams).

Range: "Ontario to Gulf of Mexico, west to Iowa and Kansas, southwest to Arizona, but not known from the southeastern Atlantic States, Virginia to Florida." (Vanatta and Pilsbry).

Michigan: Generally distributed in Lower Peninsula, Isle Royale.

Isle Royale: II, 1, Benson Brook, No. 150. A single specimen, the first record of this species from the Upper Peninsula.

Under a prostrate log in an open place near the lake.

5. *Vertigo ovata* Say.

Range: "Eastern United States from Maine to Texas and northward." (Dall).

Michigan: Generally distributed.

Isle Royale: Not collected in 1905. See Report 1904, p. 97.

6. *Vertigo gouldii* Binn.

Range: "Northern United States east of the Rocky Mountains and northward." (Dall.).

Michigan: Generally distributed.

Isle Royale: Not collected in 1905. See Report Exped. 1904, p. 97.

7.* *Vertigo tridentata* Wolf.

Range: "Quebec and Maine to Minnesota, south to Illinois and Ohio." (Pilsbry).

Michigan: Ann Arbor, Grand Rapids and Isle Royale.

Isle Royale: V. 2, Heath Zone and Beach near Siskowit Bay, No. 130 A.

A single specimen found under *Cladonia.* The first record from the Upper Peninsula.

8. *Vertigo* sp?

Isle Royale: I, 2, Natural Rock Clearings, Light-house Peninsula. Two unidentifiable fragments.

9. *Virtrina limpida* Gld.

Range: "Central New York and northward from New Brunswick to Alberta and Hudson Bay." (Dall).

Michigan: Upper Peninsula and northern counties in the Lower.

Isle Royale: V, 2, Heath Zone and Beach near Siskowit Bay, No. 130 A. A single dead specimen was found under *Cladonia.*

10. *Vitrea binneyana* (Morse).

Range: "Quebec and Maine to Northern Michigan and British Columbia." (Dall).

Michigan: Upper Peninsula and northern counties in Lower.

Isle Royale: I, 3, Balsam-Spruce Forest, No. 140; I, 5, Jack Pine Ridges, Nos. 19 A, 81; V, 2, Heath Zone and Beach near Siskowit Bay, No. 130 A; III, '04, Desor Trail, Nos. 141 A, 142 A; V, '04, Ridge back of Club House, Nos. 144 A, 147 A.

In moist soil under loose rocks (Nos. 81 and 19 A) or in the loose leaf mold under the balsam forest, No. 140; No. 130 A under *Cladonia;* Nos. 141 A and 142 A, from leaf mould or rotten logs in yellow birch or maple forest and Nos. 144 A and No. 147 A from under bark, leaves and among moss in the forest.

11. *Euconulus fulvus* (Dr.).

Range: "Holarctic, and widely distributed southward." (Dall).

Michigan: Generally distributed.

Isle Royale: I, 5, Jack Pine Ridge, No. 19 A; V, 2, Heath Zone and Beach near Siskowit Bay, Nos. 129 A, 130 A; V. '04. Ridge back of the Club House No. 147 A. No. 15 A from under a stone; Nos. 129 A and 130 A from under *Cladonia*.

12. *Euconulus chersinus polygyratus* (Pils.).

Range: Northern United States and Canada.

Michigan: Generally distributed.

Isle Royale: I, 5, Jack Pine Ridges, No. 19 A; V. 2, Heath Zone and Beach near Siskowit Bay, No. 129 A; III, '04, Desor Trail, No. 142 A; V, '04, Ridge back of Club House, No. 147 A.

Found under a damp stone (No. 19 A); under *Cladonia* (No. 129 A); in the forest under leaf mould, bark, moss or decaying logs (No. 142 A and 147 A.).

13. *Zonitoides arborea* (Say).

Range: "North America generally and Japan." (Dall).

Michigan: Generally distributed.

Isle Royale: I, 2, Natural Rock Clearings, No. 65; I, 3, Balsam-Spruce Forest, Nos. 140, 141; I, 5, Jack Pine Ridges, Nos. 19 A, 81, 102; II, 1, Ransom Clearing, No. 150; II, 2, Tamarack Swamp, No. 113; V, 2, Heath Zone and Beach near Siskowit Bay, Nos. 118 A, 129 A, 130 A; V, 4, Balsam-Birch Forest, No. 236; III, '04, Desor Trail, Nos. 142 A, 149 A; V, '04, Ridge back of Club House, No. 147 A.

In the thin soil collected under bearberry on the dry rock clearing north of the light-house (No. 65); under loose rocks in the jack pine ridges (Nos. 19 A, 81, 102); under log in an open, sunny place (No. 150); or in leaf mold in the dense shade of the balsam forest; under *Cladonia* (Nos. 118 A, 129 A, 130A); and in the dense forest among litter (Nos. 142 A, 147 A, and 149 A).

14. *Zonitoides exigua* (Stimp.).

Range: "Quebec and Ontario, New England, New York, Alleghany Co., Pa. and Michigan." (Pilsbry).

Michigan: Upper Peninsula and northern counties of the Lower.

Isle Royale: III, '04, Desor Trail, Nos. 141 A, 149 A; V, '04, Back of Club House, No. 144 A.

Found only in the dense forest among litter.

15. *Zonitoides milium* (Morse).

Range: "Eastern United States and Canada, Manitoba." (Dall.)

Michigan: Generally distributed.

Isle Royale: V, 2, Heath Zone and Beach near Siskowit Bay, No. 130 A. A single specimen under *Cladonia*.

16. *Agriolimax campestris* (Binn.).

Range: "Entire United States." (Pilsbry).

Michigan: Generally distributed.

Isle Royale: V, 2, Heath Zone and Beach near Siskowit Bay, No. 133 A. Found only under *Cladonia*.

17. *Pallifera hemphilli* (W. G. Binn.).

Range: Mountains of Georgia, North Carolina, and Eastern Pennsylvania, and Michigan.

Michigan: Isle Royale, Ontonagon County and Ann Arbor.

Isle Royale: Not collected in 1905. See Report Exped. 1904, p. 96.

18.* *Pallifera dorsalis* (Binn.).

Range: New England, New York and Michigan.

Michigan: Isle Royale, Eaton and Marquette Counties.

Isle Royale: III, '04, Desor Trail, Nos. 142 A, 149 A.

Taken only in the dense hardwood forest among litter.

19. *Pyramidula alternata* (Say).

Range: "Eastern North America as far north as Nova Scotia, Lower Canada and the international boundary." (Dall).

Michigan: Generally distributed.

Isle Royale: III, '04, Desor Trail, Nos. 142 A, 143 A, 149 A; V, '04 Ridge back of Club House, No. 144 A; VIII, '04, Upper end of Siskowit Bay, No. 232.

From the litter of the maple forest (No. 142 A and 144 A and 149 A).

20. *Pyramidula cronkhitei anthonyi* (Pilsbry).

Range: "Kansas, northward to Great Slave Lake and from New England to the Sierra Nevada and south to Arizona." (Dall).

Michigan: Generally distributed in the Lower Peninsula.

Isle Royale: I, 2, Natural Rock Clearing, No. 78; Balsam-Spruce Forest, Nos. 140, 141; I, 4, Tamarack and Arbor-vitæ Swamp, No. 182; I, 5, Jack Pine Ridge, Nos. 19 A, 81, 102; II, 1, Ransom Clearing, No. 150; V, 2, Heath Zone and Beach near Siskowit Bay, No. 129 A, 130 A; V, 4, Trail through Balsam-Spruce Forest, No. 236; III, '04, Desor Trail, Nos. 141 A, 142 A, 149 A; V, '04, Back of Club House, Nos. 144 A, 147 A.

As stated in the 1904 Report, this form is apparently replaced throughout the Upper Peninsula by the var. *catskillensis* Pils.

This species shows a wide range of habitat, and may occur under or in decaying logs (No. 78, 150); under loose rocks (19 A, 81, 102); in leaf mold (140, 141, 236). Also found under *Cladonia* (129 A and 130 A) and in the litter of the hardwood forest (141 A, 142 A, 144 A, 147 A, and 149 A).

20a. ——— var. *albina* (Ckll.).

Isle Royale: This form occurred in 1905 at I, 5, Jack Pine Ridge, No. 19 A; III, '04, Desor Trail, No. 141 A; V, '04, Back of Club House, No. 147 A.

Found under stones (No. 19 A) and in the hardwood litter (No. 141 A and 147 A.)

21. *Pyramidula asteriscus* (Morse).

Range: "Maine; Provinces of Quebec and Ontario, Canada." (Dall.) Also Northern Michigan.

Michigan: Isle Royale, Ontonagon County and Charlevoix.

Isle Royale: Not collected in 1905. See Report Exped. 1904, p. 97.

22.* *Helicodiscus parallelus* (Say).

Range: Eastern United States, Florida and Texas, north to Manitoba.

Michigan: Generally distributed.

Isle Royale: V, 2, Heath Zone and Beach near Siskowit Bay, Nos. 118 A, 129 A, 130 A.

All found among or under *Cladonia*, upon the rock beach slope.

23. *Punctum pygmæum* (Dr.).

Range: "United States generally; Quebec; Manitoba; Victoria, Vancouver Island, Europe." (Dall).

Michigan: Generally distributed.

Isle Royale: Not collected in 1905. See Report Exped. 1904, p. 97.

24. *Sphyradium edentulum* (Dr.).

Range: "Northern Europe, Asia and America." (Dall).

Michigan: Generally distributed.

Isle Royale: Not collected in 1905. See Report Exped. 1904, p. 97. One of the specimens under No. 8 may belong here.

25.* *Cochlicopa lubrica* (Mull.).

Range: "Europe, North Africa and Asia Minor; Siberia; Kamchatka; most of North America." (Dall).

Michigan: Generally distributed.

Isle Royale: II, 1, Ransom Clearing, No. 150; V, 2, Heath Zone and Beach near Siskowit Bay, No. 130 A.

No. 150 was taken under a fallen log in an open place near the lake and No. 130 A under *Cladonia* upon the rock beach.

26.* *Vallonia pulchella* (Mull.).

Range: Europe; North Africa; Southern and Western Siberia to the Amur; Madeira; the Azores; North America from Manitoba to Florida and Montana to Nova Scotia." (Dall).

Michigan: Generally distributed.

Isle Royale: A single specimen only occurred in the collections, the exact locality of which is uncertain.

27.* *Vallonia costata* (Muller).

Range: Europe; Northern United States and northward.

Michigan: Owosso, Monroe and Isle Royale.

Isle Royale: II, 1, Benson Brook, No. 150. Apparently a rare species in Michigan, and this the first record in the Upper Peninsula. Under a fallen log in an open sunny place near the lake.

28.* *Succinea ovalis* Say.

Range: "From Louisiana to Hudson Bay and eastward to New England and Gaspe, but not west of the Mississippi valley." (Dall).

Michigan: Generally distributed.

Isle Royale: V, '04, Tamarack Swamp, No. 145 A. A single dead shell was found at the margin of a small stream flowing from the swamp.

29.* *Succinea retusa* Lea.

Range: "Northern United States, from Kentucky northward to Canada and British America." (Dall).

Michigan: Generally distributed.

Isle Royale: Only a single specimen was collected, the exact locality of which was lost.

30. *Carychium exile canadense* Clapp.

Range: Northern United States and Canada.

Michigan: Generally distributed north of the Saginaw-Grand Valley.

Isle Royale: Not collected in 1905. See Report Exped. 1904, p. 97., where it is listed as *Carychium exile.*

31. *Lymnæa stagnalis* (L.). Fig. 63.

Range: "Europe; the Caucasus; Western and Northern Asia; the Northern United States; Canada and British America." (Dall).

Michigan: Generally distributed.

Isle Royale:

Variety A. (Fig. 63, No. 1.) II, 1, Mouth of Benson Brook, No. 167; II, 4, McCargoe Cove, No. 53; III, 2, Small Island in Rock Harbor, No. 89; III, 3, Bulrush Zone, Head of Rock Harbor, Nos. 161, 162, 168; III, 4, Sumner Lake Trail, on Rock Harbor, No. 156; III, 5, Sumner Lake, No. 155; III, 6, Southwest Coves of Rock Harbor, Nos. 91, 95; North side of Rock Harbor, No. 110; IV, 6, Small Island in Tobin Harbor, No. 123; Washington Harbor (Wood).

Variety B. (Fig. 63, No. 3.) I, 1, Lake and Bay Beaches, Nos. 32, 50, 57; 3rd Cove below Camp on Light-house Peninsula, No. 7; II, 1, Mouth of Benson Brook, No. 54; III, 4, Head of Sumner Lake Trail, (Wood); V, 1, Beach at Siskowit Bay, No. 200.

Variety C. (Fig. 63, No. 6.) V, 6, South shore of Siskowit Lake, Nos. 199, 210, 211, 217.

Notes on the habitats of this species are given in detail in the chapter by H. A. Gleason.

This large and widespread species seems in this country at least, to exhibit its greatest variability in the Lake Superior Region. Two well marked varieties have already been described; one var. *higleyi* Baker from Michipicoten Island on the north shore, and the other var. *sanctæ-mariæ* Walker from the St. Mary's River. It is apparently one of the most abundant species on Isle Royale, where three very distinct forms are represented, none of which are typical and none exactly coincident with any of the described varieties. All the specimens collected fall into one of these groups which are apparently correlated with definite local conditions. For present purposes they may be designated as varieties A. B. and C. Variety A (Fig. 63, No. 1) most closely approaches to the usual North American form known as var. *appressa* Say (Fig. 63, No. 4) from which it differs mainly in the pear-shaped rather than regularly rounded aperture. It is characteristic of the quieter waters of the long, narrow harbors which are such a remarkable feature of the island. The same form has also been collected in the St. Mary's River near the Neebish Rapids. Variety B is an inhabitant of the shores exposed to the more violent waves of the main lake. Correlated with these conditions the shell is smaller, with a short spire and a relatively large body whorl for the accommodation of the large foot necessary to enable it to retain its hold upon the rocks, among which it lives. This form (Fig. 63, No. 3) is more nearly related to the var. *higleyi* (Fig. 63, No. 5) from the north shore, but is apparently much smaller. It is about the size of the

var. *sanctæmariæ* (Fig. 63, No. 2) but quite different in the shape of the spire. Variety C. (Fig. 63, No. 6) is the largest in cubic capacity yet known from this country. It was found only in Siskowit Lake, whose quiet waters and especially favorable conditions have conduced to the production of this unusually fine, thin, inflated form.

32.* *Lymnæa megasoma* Say.

Range: "Northern New England, Canada, and British America to Lat. 57° N." (Dall). Also Northern Michigan, Wisconsin and Minnesota.

Michigan: Isle Royale, St. Mary's River and Roscommon County.

Isle Royale: IV, 3, Bayou at Tobin Harbor, No. 124, (Adams). A single large, but dead, specimen was found in a pond-like bayou which was connected with Tobin Harbor by a very narrow and short outlet.

33. *Lymnæa emarginata* Say.

Range: "Northern United States east of the Mississippi, Canada and northward." (Dall).

Michigan: Shores of the Great Lakes north of Saginaw Bay and some inland lakes from Roscommon County northward.

Isle Royale: I, 1, Lake and Bay Beaches, Nos. 24, 50, 57, 58, 59, 74, 118, and 125; 3rd Cove west of Camp on Light-house Peninsula, No. 7; III, 4, Head of Sumner Lake Trail, (Wood); V, 1, Beach at Siskowit Bay, No. 200.

This is a characteristic and abundant species along the lake beach where it was found associated with var. B. of *Lymnæa stagnalis*. The same form, but with a rather heavier shell, is very abundant along the shore of Mackinac Island. Specimens from one rock pool, No. 58, are peculiar in being longitudinally striped with white like *Lymnæa reflexa zebra* Tryon. Those from another, Nos. 59 and No. 74, are unicolored.

34. *Lymnæa pilsbryana* Walker.

(Nautilus, XXII, p. 4, Pl. I, fig. 2, 8-11, 1907).

Range: Isle Royale is the only known locality.

Isle Royale: X, '04, Washington Harbor, No. 1 (Wood). This form, so far as the collections show, is apparently confined to the west end of the island. It was doubtfully referred to *Lymnæa sumassi* Bd. in the Report Exped. 1904, p. 97. A larger suite of specimens from the original locality in Washington Harbor was collected in 1905, including a few full grown examples which confirm its specific distinctness.

35.* *Lymnæa obrussa* Say.

Range: "Northern United States and Northward." (Dall).

Michigan: Generally distributed.

Isle Royale: III, 2, Small Island in Rock Harbor, No. 89; III, 3, Bulrush Zone at western end of Rock Harbor, No. 164.

36.* *Lymnæa catascopium* Say.

Range: "Northern United States to Rocky Mountains, Canada and northward." (Dall).

Michigan: Shores of the Great Lakes and connecting rivers and lower waters of tributaries in northern counties.

Isle Royale: North shore of Rock Harbor, No. 110; III, 3, Bulrush Zone at western end of Rock Harbor, Nos. 160, 163, 164; III, 6, Southwest Coves of Rock Harbor, No. 91; IV, 2, Island No. 14, Tobin Harbor, No. 30 A; IV, 6, Small Island in Tobin Harbor, No. 123; V, 6, South shore of Siskowit Lake, No. 220.

Apparently most frequent in shallow water in places sheltered from the waves, but No. 220, a single very young specimen, was collected on the under surface of a water-lily leaf.

With one exception, the specimens from all these localities are alike and belong to the common, rather short, lake form of this species. Associated with this form at Station IV, 6, was a very thin, elongated form with the characteristic sculpture of *catascopium,* which is closely related to, but much more fragile than, the elongated form, which is characteristic of the lower Great Lakes.

37. *Limnæa* sp?

Isle Royale: III, 3, Bulrush Zone at western end of Rock Harbor, No. 163; IV, 2, Island No. 14 in Tobin Harbor, No. 126.

At both these localities occurred a few dead, fragmentary and more or less decayed specimens, which could hardly be referred to any of the species listed above, and yet were too imperfect to successfully identify.

38. *Physa sayii* Tapp.

Range: Northern United States and Canada.

Michigan: Generally distributed.

Isle Royale: I, 1, Lake and Bay Beaches, Nos. 50, 57, 118, 125; 3rd Cove west of Camp on Light-house Peninsula, No. 7; III, 4, Head of Sumner Lake Trail, (Wood); V, 1, Beach at Siskowit Bay, No. 200; Washington Harbor, (Wood).

The specimens from Washington Harbor are of normal thickness and more nearly typical in shape than those from the other localities, which are unusually thin.

More detailed notes on the local distribution of this species are given in the chapter by H. A. Gleason.

30.* *Physa gyrina* Say.

Range: "The United States east of the Mississippi, Canada and northward." (Dall).

Michigan: Generally distributed.

Isle Royale: II, 5, Forbes Lake, Nos. 71 A, 90; III, 5, Southwest Coves of Rock Harbor, No. 91.

Specimens No. 71 A were found on driftwood in water a few inches deep.

The specimens from Forbes Lake are a very large, inflated form. Those from the other locality are much smaller and may be one of the varying forms of No. 41, though closer to typical *gyrina* than those included under that head.

40.* *Physa aplectoides* Sterki.

Range: "Tuscarawas County, Ohio, and elsewhere." Sterki.

Michigan: Isle Royale.

Isle Royale: V, 11, Tamarack Swamp, No. 128 A.

Taken from foot-print pools in the Sedge and Buck Bean Zone about a small pond.

The occurrence of this minute species so far from its original locality in Ohio, was one of the surprises of the 1905 collection. It is a very distinct form resembling a young *Aplexa hypnorum* in shape but beautifully sculptured, especially on the apical whorls. The identification is based on comparison with topotypes of *aplectoides* received from Dr. V. Sterki.

41. *Physa* sp?

Isle Royale: II, 1, Benson Brook, No. 149, 167; III, 2, Island at West end of Rock Harbor, No. 89; II, 3, Bulrush Zone at western end of Rock Harbor, Nos. 161, 162, 163, 164; North shore of Rock Harbor, No. 110; III, 5, Sumner Lake, Nos. 77 A, 78 A, 79 A; IV, 5, Neutson's Resort at Rock Harbor, No. 44 A; IV, 6, Island in Tobin Harbor, No. 123; IV, 7, Head of Tobin Harbor, No. 127; V, 1, Beach near Siskowit Bay, No. 200; V, 6, South shore of Siskowit Lake, Nos. 220, 221; V, 9, Outlet of Siskowit Lake, No. 238; V, 11, Swamp near Siskowit Bay, No. 126 A.

Under this head are included nearly all the *Physæ* from the harbors and interior waters which, although exhibiting considerable variation in shape and size, appear to be variation of a common form. Most of the specimens are immature. The few mature examples at first glance would naturally be referred to *Physa heterostropha* Say, but the uniform sculpture of the apical whorls, which becomes more or less obsolete on the body whorl of the mature shell, forbids their reference to that species. The sculpture is that of *gyrina* and the form may ultimately referred to that species as an extreme form, but the shape of the immature shell, its small, acute spire and deeply impressed suture is quite different from that of typical *gyrina*. In the present chaotic state of the nomenclature of the American species of *Physa* it would seem the better policy to refrain from any attempt at specific identification than to run the risk of adding to an already over-burdened synonymy.

42. *Aplexa hypnorum* (L.).

Range: "Northern Europe, Asia and America. Northern United States and Canada." (Dall).

Michigan: Generally distributed.

Isle Royale: Not collected in 1905. See Report Exped. 1904, p. 98.

43. *Planorbis trivolvis* Say.

Range: "Entire Atlantic Drainage of North America; and the Mississippi Valley and northward." (Dall).

Michigan: Generally distributed.

Isle Royale: III, 5, Sumner Lake, Nos. 78 A, 135.

In a small pool in the sedge zone of a tamarack swamp.

44. *Planorbis bicarinatus* Say.

Range: "The United States East of the Rocky Mountains; Eastern Canada; Oregon." (Dall).

Michigan: Generally distributed.

Isle Royale: III, 2, Small Island in Rock Harbor, No. 89; III, 3, Bulrush Zone at western end of Rock Harbor, Nos. 159, 160; III, 6, Southwest Coves of Rock Harbor, No. 91.

Dredged from the mud bottom at the upper end of Rock Harbor, near mouth of a small stream, in 3-5 feet of water (Nos. 159, 160).

44a. ——— var. *striatus* Baker.

Isle Royale: III, 3, Bulrush Zone at western end of Rock Harbor, No. 162; III, 5, Sumner Lake, Nos. 78 A, 79 A.

Dredged from the mud bottom of the small sluggish stream at the head of Rock Harbor (No. 162) and from the margin and sedge zone of Sumner Lake (No. 78 A, 79 A.).

44b.* var. *royalensis* Walker.

(Nautilus, XXII, p. 9-10, Pl. I, fig. 11, (1909).

Isle Royale: V, 6, South shore of Siskowit Lake, No. 210.

This novel and very distinct form, characterized by its very acute carinæ and rough, irregularly corrugated surface, was one of the most interesting discoveries of the expedition.

In the mud among loose stones at a depth of about 1 foot.

45. *Planorbis campanulatus* Say.

Range: "Atlantic, Mackenzie and Hudson Bay water sheds and north to Great Slave Lake." (Dall).

Michigan: Generally distributed.

Isle Royale: III, 5, Sumner Lake, Nos. 78 A, 79 A; V, 6, South shore of Siskowit Lake, Nos. 210, 211.

In mud and among loose stones at a depth of about one foot (Nos. 210, 211) and in small pools in the Sedge Zone (Nos. 78 A, 79 A).

The specimens from Sumner Lake are the usual form. Those from Siskowit Lake are a peculiar variety resembling the rare *Planorbis multivolvis* Case, in having apparently the apical whorls elevated above the line of the body whorl. Unfortunately the upper surface of all the specimens collected is so eroded that it is impossible to determine just what degree of elevation the spire of the perfect shell attains.

46. *Planorbis exacuous* Say.

Range: "Northern United States, east of the Rockies; Canada, etc., south to New Mexico." (Dall).

Michigan: Generally distributed.

Isle Royale: III, 2, Small Island in Rock Harbor, No. 89; III, 3, Bulrush Zone at the western end of Rock Harbor, Nos. 159, 160, 161, 162.

In the muddy bottom of a small stream flowing into Rock Harbor and in the Harbor itself, at a depth of 2-5 feet (Nos. 159 to 163).

47. *Planorbis parvus* Say.

Range: "Eastern North America from Florida to North Lat. 67°, and the Yukon Drainage System." (Dall).

Michigan: Generally distributed.

Isle Royale: I, 1, Rock Pool, No. 2, Light-house Peninsula, No. 59; III, 2, Small Island at Rock Harbor, No. 89; III, 3, Bulrush Zone at western end of Rock Harbor, Nos. 159, 160, 163, 164; III, 5, Sumner Lake, No. 79 A; III, 6, Southwest Coves of Rock Harbor, No. 91.

As with the last species (Nos. 159, 160,, 163 and 164).

48. *Planorbis hirsutus* Gld.

Range: "Washington, D. C., northward east of the Mississippi." (Dall).

Michigan: Generally distributed.

Isle Royale: Not collected in 1905. See Report Exped. 1904, p. 98.

49. *Ancylus* sp?

Isle Royale: I, 3, Balsam-spruce Forest, No. 140.

"In the damp leaf mold in the dense shade of the balsam-spruce forest."

A single broken specimen, too much damaged to identify specifically, was the only one obtained. There is apparently some mistake in regard to the locality where this specimen was found.

50. *Valvata tricarinata* Say.

Range: "From New England and Virginia westward to Missouri and northward." (Dall).

Michigan: Generally distributed.

Isle Royale: III, 2, Small Island in Rock Harbor, No. 89; III, 3, Bulrush Zone at western end of Rock Harbor (Nos. 160, 163).

In the mud in deep water at the head of Rock Harbor (Nos. 160, 163).

51. *Valvata lewisii* Currier.

Range: "Northern United States from Atlantic to Pacific and Northward." (Dall).

Michigan: Generally distributed.

Isle Royale: Not collected in 1905. See Report Exped. 1904, p. 98, cited as *Valvata sincera lewisii*.

52. *Valvata sincera nylanderi* Dall.

Range: Northern United States from Maine to Wisconsin.

Michigan: Isle Royale and Marquette County.

Isle Royale: III, 2, Small Island in Rock Harbor, No. 89; III, 3, Bulrush Zone at western end of Rock Harbor, Nos. 159, 160, 163, 164; V, 6, South Shore of Siskowit Lake, No. 220.

With *Valvata tricarinata* at the head of Rock Harbor and in shallow water in Siskowit Lake (No. 220), especially abundant on the lower side of water-lily leaves.

53. *Amnicola limosa* (Say).

Range: "Virginia to Wisconsin and Hudson Bay." (Dall).

Michigan: Generally distributed.

Isle Royale: V, 6, South shore of Siskowit Lake, No. 220, living in company with the preceding species under water-lily leaves.

54. *Amnicola lustrica* Pils.

Range: Northern United States.

Michigan: Generally distributed.

Isle Royale: III, 2, Small Island in Rock Harbor, No. 89; III, 3, Bulrush Zone at western end of Rock Harbor, Nos. 159, 160, 163, 164.

In muddy bottom in deep water (3-5 feet deep) at the head of Rock Harbor.

55. *Lampsilis luteola* (Lam).

Range: "Entire Mississippi drainage and north to the Red River of the North." (Dall).

Michigan: Generally distributed.

Isle Royale: V. 6, South shore of Siskowit Lake, Nos. 210, 211, 218.

Some of the specimens collected are very similar to the form from the Beaver Islands, Lake Michigan, referred to *Lampsilis borealis* Gray, but they are connected by intermediate specimens with the more typical form and seem rather referable to this species than to *borealis*.

56. *Anodonta grandis footiana* Lea.

Range: Northern United States and northward.

Michigan: Generally distributed.

Isle Royale: II, 4, McCargoe Cove, No. 52; III, 2, Small Island in Rock Harbor, No. 89; III, 3, Bulrush Zone at western end of Rock Harbor, No. 168; III, 4, near head of Trail to Sumner Lake, Rock Harbor, No. 93; III, 5, Sumner Lake, No. 154; III, 6, Southwest Coves of Rock Harbor, Nos. 91, 91, 156; South Side of Rock Harbor, Nos. 109;

V, 6, South Shore of Siskowit Lake, Nos. 210, 211, 218; Sargent Lake, No. 112.

Abundant in all of the lakes, especially on sandy or gravelly bottom in the smaller coves sheltered from the waves.

57. *Anodonta marginata* Say.

Range: "Drainage of the St. Lawrence River basin, including the Lakes." (Dall).

Michigan: Generally distributed.

Isle Royale: II, 1, Benson Brook Clearing, No. 80 A; II, 5, Forbes Lake, No. 90; III, 5, Sumner Lake, Nos. 94, 120, 135, 139, 154, 186, (Wood); IV, 3, Bayou at Tobin Harbor, No. 124; V, 6, South shore of Siskowit Lake, No. 210; VII, '04, Lake Desor, No. 139 A.

58.* *Sphaerium simile* (Say).

Range: "United States east of the Mississippi River; Canada, Manitoba." (Dall).

Michigan: Lake Michigan and Lake Superior.

Isle Royale: III, 5, Sumner Lake. Only two immature valves taken.

59.* *Sphaerium walkeri* Sterki.

Range: Lake Michigan and Northward.

Michigan: Generally distributed.

Isle Royale: III, 2, Small Island in Rock Harbor, No. 89. A single fragmentary specimen is doubtfully referred to this species by Dr. V. Sterki.

60.* *Musculium securis* (Prime).

Range: Northern United States, Maine to Minnesota.

Michigan: Generally distributed.

Isle Royale: III, 3, Bulrush Zone, Rock Harbor, No. 160; III, 5, Sumner Lake, Nos. 77 A, 78 A, 79, 176; V, 9, Outlet of Siskowit Lake, No. 238. A few examples only of a small form. Some immature examples from the latter locality "may be the same."

In small, shallow pools in the outlet of Siskowit Lake (No. 238) and at the margin and Sedge Zone of Sumner Lake (No. 77 A, 78 A).

61.* *Pisidium idahoense* Roper.

Range: Idaho; Washington; Alaska; Lake Michigan; Lake Superior.

Michigan: Lake Michigan and Lake Superior.

Isle Royale: III, 2, Small Island in Rock Harbor, No. 89; III, 3, Bulrush Zone, Rock Harbor, Nos. 159, 160, 162, 163. Rather common. The Isle Royale form is similar to that from Lake Michigan and is neither as large nor as inflated as the typical form.

Dredged from a muddy bottom in 2-5 feet of water at the head of Rock Harbor and in a small stream flowing into it. (Nos. 159, 160, 162, 163.)

62. *Pisidium variabile* Prime.

Range: "Eastern United States, north of Virginia; Colorado and northward." (Dall).

Michigan: Generally distributed.

Isle Royale: III, 5, Sumner Lake, 77 A; III, 2, Small Island in Rock Harbor, No. 89; III, 3, Bulrush Zone, Rock Harbor, Nos. 160, 162, 163; V, 9, Outlet of Siskowit Lake, No. 238.

With the last at the head of Rock Harbor, and also in the small

pools with gravel bottom in the outlet from Siskowit Lake and at the margin of Sumner Lake.

62a.* var. *brevius* Sterki.

Range: "Michigan; Minnesota and Keewatin." (Sterki.)

Michigan: Upper Peninsula and northern part of the Lower Peninsula.

Isle Royale: III, 3, Bulrush Zone, Rock Harbor, Nos. 160, 164. All the examples both of the typical form and the variety are "small and mostly immature."

With the typical form in the mud bottom in 3-5 feet of water at the head of Rock Harbor.

63.* *Pisidium affine* Sterki.

Range: "Great Lake Region, Michigan to New York; Minnesota, Illinois and Ohio (Ohio River Drainage)." (Sterki).

Michigan: Generally distributed.

Isle Royale: III, 5, Sumner Lake, Nos. 77 A, 79 A. A few examples, "quite small," from the margin and Sedge Zone.

64.* *Pisidium sargenti* Sterki?

Range: "Northern United States, New York to Minnesota." (Sterki).

Michigan: Generally distributed in Lower Peninsula; Isle Royale.

Isle Royale: III, 5, Sumner Lake, No. 176. Two specimens only, which "may be *Pisidium sargenti*. One example is large, especially in contrast with the small forms of the other species. In the smaller specimen the hinge is partly reversed."

65.* *Pisidium scutellatum* Sterki.

Range: Northern United States, Michigan to Washington and northward.

Michigan: Generally distributed.

Isle Royale: III, 2, Small Island in Rock Harbor, No. 89; III, 3, Bulrush Zone, Rock Harbor, Nos. 159, 160, 163, 164; "Small, northern variety. The most common species and somewhat variable."

In the mud and silt bottom in 10 inches to 5 feet of water at the upper end of Rock Harbor (Nos. 159, 160, 163).

66.* *Pisidium roperi* Sterki.

Range: Northern United States, Maine to Minnesota.

Michigan: Generally distributed.

Isle Royale: III, 5, Sumner Lake, No. 78; IV, 8, Trail to Greenstone Range, No. 128. "Small, but good and characteristic."

67.* *Pisidium ventricosum* Prime.

Range: Northern United States, Maine to Michigan and northward.

Michigan: Western part of the State, Kent County to Charlevoix County; Marquette County; Isle Royale.

Isle Royale: III, 5, Sumner Lake, Nos. 77 A, 79 A; III, 2, Small Island in Rock Harbor, No. 89; III, 3, Bulrush Zone at Rock Harbor, Nos. 163, 164.

In 10 inches of water in the *Potamogeton* Zone at the mouth of a creek at the upper end of Rock Harbor (No. 163) and at the margin and in the sedge of Sumner Lake.

68.* *Pisidium subrotundum* Sterki.

Range: "New England; Anticosti Island to Michigan." (Sterki).

Michigan: Kent, Marquette and Ontonagon counties and Isle Royale.

Isle Royale: I, 6, Sphagnum-Spruce Bog, No. 116; IV, 8, Trail to Greenstone Range, No. 128; III, 3, Bulrush Zone at western end of Rock Harbor, Nos. 159, 160; I, 4, Tamarack and Arbor Vitæ Swamp, Nos. 181, 182; V, 5, Tamarack Swamp, No. 237; V, 9, Outlet of Siskowit Lake, No. 238. A "form" of this species "common and somewhat variable."

Among dead leaves and sedges at the bottom of shallow pools in a tamarack swamp (No. 116). In silt and debris on the bottom in 4-5 feet of water (Nos. 159, 160); small sphagnum-lined pools, seldom exceeding six inches in depth in dense shade (Nos. 181, 182); among sphagnum and *Utricularia* in small streams and pools, mostly in the sun (No. 237); in shaded, shallow pools with gravelly bottom (No. 238).

69.* *Pisidium rotundatum* Prime.

Range: Northern United States, Maine to Minnesota and northward.

Michigan: Generally distributed.

Isle Royale: I, 6, Sphagnum-spruce Bog, No. 116; III, 3, Bulrush Zone, Rock Harbor No. 160; V, 5, Tamarack Swamp, No. 237; "Few and probably none mature."

Among dead leaves and sedges at the bottom of shallow pools, in shade (No. 116); among sphagnum and *Utricularia* in small, shallow streams and pools, mostly in the sun (No. 237.)

70.* *Pisidium splendidulum* Sterki.

Range: Northern United States, Maine to Michigan.

Michigan: Generally distributed.

Isle Royale: III, 5, Sumner Lake, Nos. 77 A, 79 A, 176. At margin and in the Sedge Zone.

71.* *Pisidium pauperculum* Sterki.

Range: Northern United States, Maine to Minnesota.

Michigan: Generally distributed.

Isle Royale: III, 3, Bulrush Zone at western end of Rock Harbor, No. 164. A few specimens of a small form.

72.* *Pisidium medianum* Sterki.

Range: Northern United States, Maine to Wisconsin.

Michigan: Generally distributed.

Isle Royale: III, 5, Sumner Lake, Nos. 77 A, 78 A, 79 A; III, 2, Small Island in Rock Harbor, No. 89; III, 3, Bulrush Zone at western end of Rock Harbor, Nos. 160, 164; V, 9, Outlet of Siskowit Lake, No. 238.

Near the mouth of a small creek, on a silt and mud bottom at a depth of 5 feet (No. 160); In shallow, shaded pools with gravelly bottom (No. 238).

73.* *Pisidium punctatum simplex* Sterki.

Range: "Michigan, Wisconsin and Illinois." (Sterki.)

Michigan: Carp Lake, Emmet Co. and Isle Royale.

Isle Royale: III, 3, Bulrush Zone at Western end of Rock Harbor, No. 160.

74.* *Pisidium milium* Held.

Range: Europe; Maine and Michigan.

Michigan: Generally distributed.

Isle Royale: III, 3, Bulrush Zone at western end of Rock Harbor, Nos. 160, 162. No. 162 occurred in a small creek near its mouth, on a silt and debris-covered bottom at a depth of 3 feet.

75. *Pisidium abditum* Haldeman.

Range: "North America, from Honduras, north to Alaska." (Dall).

Michigan: Generally distributed.

Isle Royale: Not found in 1905. See Report Exped., 1904, p. 98.

76. *Pisidium* sp.?

Isle Royale: Undetermined forms of Pisidium were collected in the following localities: III, 3, Bulrush Zone at western end of Rock Harbor, Nos. 159, 160, 163; V, 5, Tamarack Swamp, No. 237.

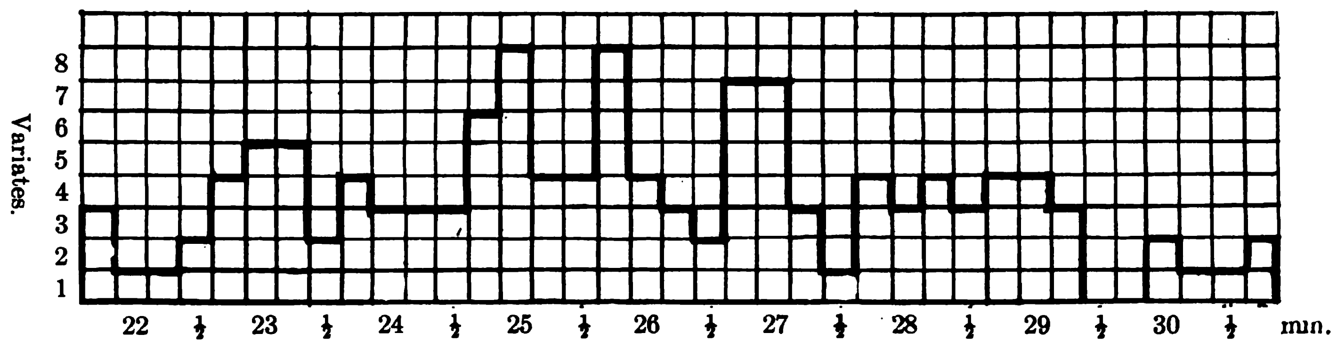

FIG. 61. VARIATIONS IN THE SHELL WIDTH OF POLYGYRA ALBOLABRIS.

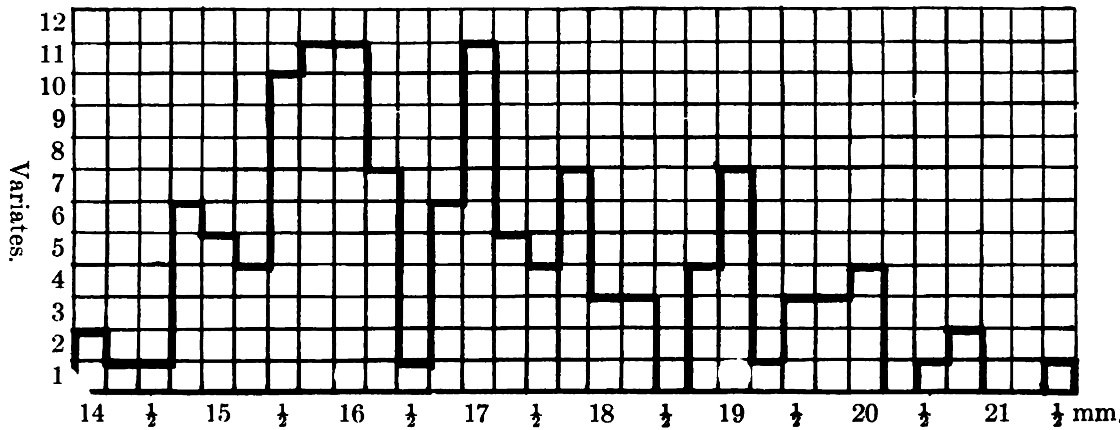

FIG. 62. VARIATION IN THE SHELL HEIGHT OF POLYGYRA ALBOLABRIS.

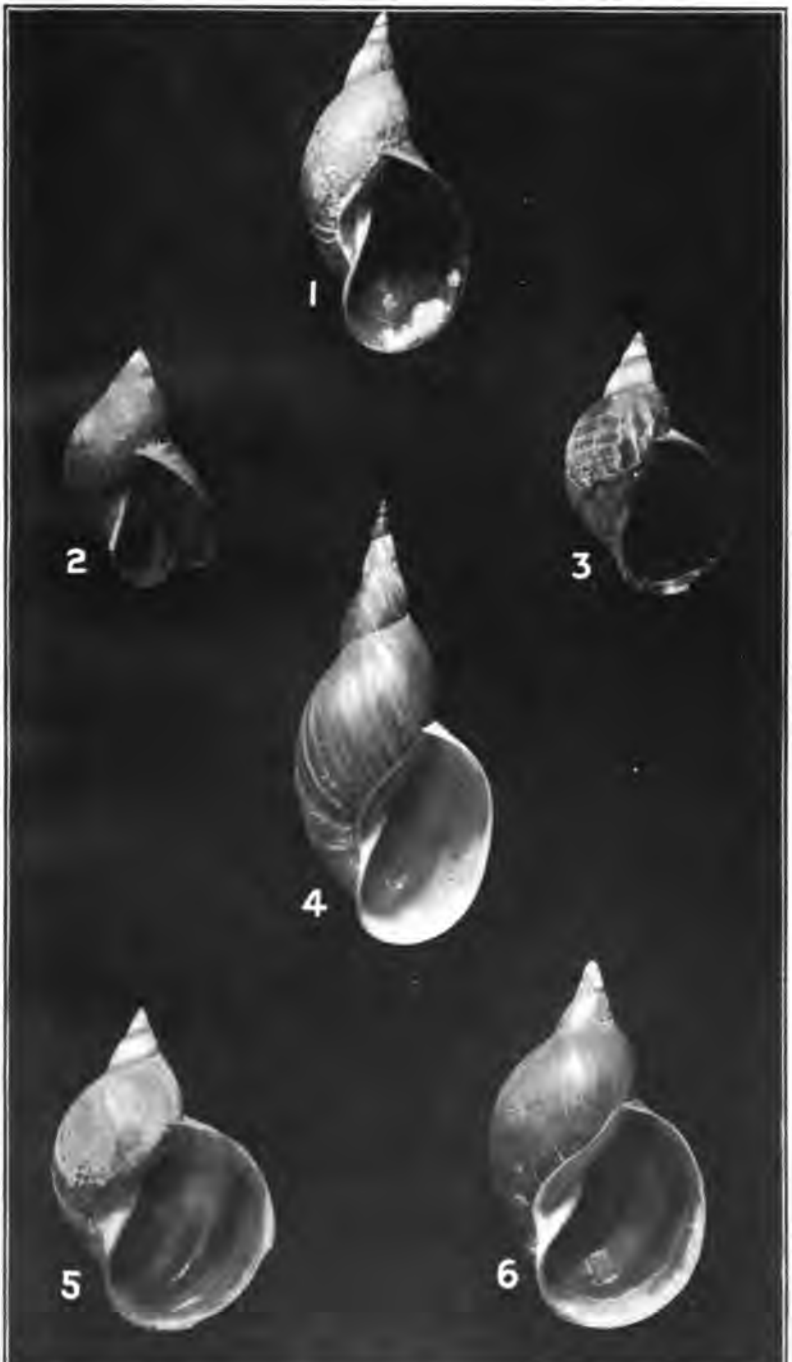

FIG. 63. LYMNAEA STAGNALIS VARIETIES FROM ISLE ROYALE.

REPORT ON THE ISLE ROYALE ORTHOPTERA OF THE 1905 EXPEDITION.

ALBERT P. MORSE, RESEARCH ASSISTANT, CARNEGIE INSTITUTION OF WASHINGTON.

1. *General Remarks.*

The orthoptera secured by the University Museum expedition of 1905 to Isle Royale consist of representatives of 13 species. Of these, one is a cosmopolitan roach, the Croton-bug, *Blattella germanica,* doubtless introduced in merchandise through man's agency. The others, with a single exception, are boreal Acridians characteristic of the cooler parts of central and eastern North America, whose presence in this locality was either known or to be confidently expected. The exception, *Melanoplus alaskanus,* is a species hitherto known only from the Northwest, whose presence on Isle Royale, in sufficient numbers to make it appear to be the dominant species of its genus there, was, to say the least, unlooked for. It would be of much interest in this connection to know the status of this species on the adjoining northern mainland.

Some striking variations are present in the representatives of certain species and will be found noted in the following list. In general, there seems to be a tendency toward an increased duskiness of coloring as shown by *Camnula pellucida, Hippiscus tuberculatus,* and *Circotettix verruculatus* (all geophilous species), due perhaps to humidity, perhaps to environmental coloration; also, as compared with eastern material, the specimens are of relatively large size, particularly in the cases of *Melanoplus extremus* and *fasciatus.*

The locust societies represented consist of campestral and thamnophilous groups, though all of the species are to be obtained in the clearings or about their edges, rather than in the forest.

The thamnophile species are *Chloealtis conspersa* and *abdominalis, Melanoplus fasciatus* and *huroni.* The campestral species, notwithstanding the generally forested character of the country, are more numerous and consist both of phytophilous and geophilous species. In the damper situations occur *Stenobothrus curtipennis, Mecostethus lineatus, Melanoplus extremus* and *femoratus.* In drier places *Camnula pellucida, Melanoplus alaskanus,* and *Hippiscus tuberculatus* are to be found. Characteristic of the bare rock ridges is the saxicolous *Circotettix verruculatus.* The two latter species, with their strikingly colored wings and noisy flight, are the most conspicuous members of the orthopterous fauna of the island.

The 1904 expedition secured examples of a Tettigid (*Tettix acadicus*) and of a wingless Locustarian—*Ceuthophilus seclusus.* The species of *Ceuthophilus* usually inhabit damp, dark places, under bark, in hollow logs, etc., and are among the most characteristically sylvan of our orthoptera.

The lot numbers refer to the field numbers of the collectors, those without a letter to H. A. Gleason and those followed by an A. to C. C. Adams.

2. *Annotated List of Species.*

Blattidae.

1. *Blattella germanica* Linn. Croton-bug. Station I, 7, camp. Lot 179. July 28. A single female with oötheca. Probably introduced in merchandise.

Acridiidae.

2. *Stenobothrus curtipennis* Harr. Stations I, 7, camp; V, 3; V, 5; I, '04 and VIII, '04. Lots 99 A., 134 A., 137, 228, 232. July 24 to Aug. 24.

This species is a characteristic inhabitant of moist, grassy or sedgy meadows. It was taken in the cassandra and hummock zone at V, 5, and in a clearing near end of Wendigo road at Washington Harbor. Both long—and short-winged forms were secured.

3. *Chloealtis abdominalis* Thom. Stations II, 3; IV, 5; and I, '04. Lots 121, 143, 154 A. July 21, 25, Aug. 24. A young male in 5th stage on July 21.

4. *Chloealtis conspersa* Harr. Stations I, 1; II, 3; and I, '04. Lots 22, 143, 144, 147, 154 A. July 6 to Aug. 24. A young male in 5th stage on July 6. Some of the males of this species show indications of the more closely reticulated spot in the tegmina so characteristic of *abdominalis.*

The species of this genus are dwellers in thicket and woodland edges, ovipositing usually in decayed, though sometimes in firm, wood.

5. *Mecostethus lineatus* Scudd. Stations II, 5; V, 5; V, 11; and I, '04. Lots 91 A., 136 A., 154 A., 180. July 8 to Aug. 24.

Numerous immature examples of this genus are referred to this species with some doubt, and it is quite possible that some of them belong to an allied species. The hind tibiae of these young specimens are markedly fuscous.

6. *Camnula pellucida* Scudd. Stations I, 7; IV, 5; V, 3; and I, '04. Lots 121, 133, 222, 228, 154 A. July 21 to Aug. 24. Young in 4th and 5th stages on July 21 and 22.

The representatives of this species, like those of some others, are unusually dark in color, a phase of coloration probably correlated with the humid climate or soil background. This is a campestral species, occurring plentifully from Atlantic to Pacific oceans in the boreal zone, usually upon dry, upland soil.

7. *Hippiscus tuberculatus* Palis. Coral-winged Locust. Stations IV, 5; IV, 9; V, 9. Lots 121, 122, 215. July 21 to Aug. 7.

This species is represented by 6 males, 4 females, which differ markedly from typical eastern examples in being deeply infuscated, the hind tibiae coral red except on basal half of outer side, and in having the posterior process of the pronotum more produced.

This large locust is an inhabitant of clearings on dry soil. Its bright-

colored wings (whence the name of Coral-winged Locust is derived) render it a conspicuous object during its powerful and usually sustained flight.

8. *Circotettix verruculatus* Kirby. Stations I, 5; I, 7; II, 3; III; IV, 5; V, 2; V, 3; V, 9. Lots 121, 131, 132, 144, 108, 147, 179, 208, 201, 212, 215, 222, 239, 27, 107 A., 135 A. July 20 to Aug. 16.

This species is represented by numerous specimens, in general very dark in color, which were secured in the cladonia zone, the beach heath zone, rock clearings and ridges. It is a typically saxicolous locust, delighting to sun itself on outcropping ledges of rock or the neighboring patches of bare soil and usually presents a very close resemblance in coloration to its background.

9. *Melanoplus alaskanus* Scudd. Stations I, 7; II, 3; IV, 5; IV, 9; V, 2; V, 9; V, 11; and I, '04. Lots 55, 121, 122, 133, 137, 144, 146, 147, 166, 179, 215, 216, 107 A., 154 A., 136 A. July 21 to Aug. 24.

This species, described from Alaska, is apparently the dominant form of the genus occurring on Isle Royale, to judge from its abundance in the material examined and the localities whence derived. It is recorded from clearings, along trails, rock ridges, the beach heath zone, etc. As the original description was based on a small series of specimens, measurements follow to show the range of size in the material at hand. The coloration varies much individually, recalling that of *femur-rubrum* in cool, moist regions.

Length of body: ♂ 20-23.5; ♀, 23-29. Hind femora: ♂, 12-14; ♀, 12-14.5. Tegmina: ♂, 19-20.5; ♀, 17.5-23 mm.

10. *Melanoplus extremus* Walk. Stations II, 5; V, 5; V, 11. Lots 180, 99 A., 136 A. July 8 to Aug. 16.

This species was found in the cassandra and sedge zone of the swamps, and on the jack pine ridge. It is a typical inhabitant of moist meadows throughout the Canadian zone from Alaska to Nova Scotia. The examples secured are of large size and measurements are appended.

Length of body: ♂, 20-21; ♀, 26 29. Hind femora: ♂, 11.7 12.7; ♀, 13.5-14.5 Tegmina: ♂, 11.5-14.5; ♀, 13.5-15.5 mm.

11. *Melanoplus fasciatus* Barnst.-Walk. Stations II, 3; III; V, 2; V, 3; IV, 5; V, 9; III, '04. Lots 121, 131, 144, 146, 193, 207, 208, 212, 214, 231, 215, 222, 239, 101 A., 107 A., 135 A., 143 A. July 20 to Aug. 16.

This is a common and widely distributed species in the procumbens, heath and cladonia zones. It is a thamnophilous species in the east, and typically short-winged, but in the central part of the continent examples with fully developed wings and tegmina are not rare, and both forms are represented among the material secured. The average size is considerably greater than that of specimens from the east and measurements are appended.

Length of body: ♂, 19-23; ♀, 23-27. Hind femora; ♂, 10.7-12; ♀, 12-13.5. Tegmina; ♂, 11.5-18.5 (average 12.5); ♀, 10.5-18 mm.

12. *Melanoplus femoratus* Burm. Station I, 7, camp. July 24. Lot 137, a single male.

13. *Melanoplus huroni* Blatchley. Stations I, Light-house Peninsula; I, 5; III, 5; IV, 5; IV, 7. Lots 35, 44, 121, 131, 183, 35 A. July 8 to 29. Seven females from dry, aspen-covered, burned-over ridge, rock clearings and ridges.

The Melanopli have been determined from adult examples solely. There are in addition numerous immature specimens, in several stages, representing at least three species and possibly more, which cannot be identified with certainty at present.

3. *Station List, 1905 Collections.*

I, 1. Lake Superior and Bay Beaches.
Chloealtis conspersa, (No. 22).
I, 5. Jack Pine Ridge.
Circotettix verruculatus, (108, 27).
Melanoplus huroni, (44).
I, 7. Camp at Light-house Clearing.
Blattella germanica, (179).
Stenobothrus curtipennis, (137).
Camnula pellucida, (133).
Circotettix verruculatus, (179).
Melanoplus alaskanus, (133, 137, 166, 179).
Melanoplus femoratus, (137).
II, 3. Rock Ridge Clearings on McCargoe Cove Trail.
Chloealtis conspersa, (143, 144, 147).
Chloealtis abdominalis, (143).
Circotettix verruculatus, (147, 144).
Melanoplus alaskanus, (144, 146, 147, 55).
Melanoplus fasciatus, (144, 146).
II, 5. Forbes Lake.
Mecostethus lineatus, (180).
Melanoplus extremus, (180).
III. Western End of Rock Harbor.
Circotettix verruculatus, (131, 132).
Melanoplus fasciatus, (131).
Melanoplus huroni, (131).
III, 5. Sumner Lake.
Melanoplus huroni, (183).
IV, 5. Clearing at Neutson's Resort.
Chloealtis abdominalis, juv., (121).
Camnula pellucida, (121).
Hippiscus tuberculatus, (121).
Circotettix verruculatus, (121).
Melanoplus alaskanus, (121).
Melanoplus huroni, (121).
Melanoplus fasciatus, (121).
IV, 7. Head of Tobin Harbor.
Melanoplus huroni, (35 A.).
IV, 9. Mountain Top.
Hippiscus tuberculatus, (122).
Melanoplus alaskanus, (122).
V, 2. Heath Zone and Beach.
Circotettix verruculatus, (A. 135, A. 107).
Melanoplus alaskanus, (107 A.).
Melanoplus fasciatus, (101 A, 135 A, 107 A).

V, 3. Rock Clearing at Camp on Siskowit Bay.
Stenobothrus curtipennis, (99 A., 228).
Camnula pellucida, (222, 228).
Circotettix verruculatus, (239, 222, 208, 201, 212).
Melanoplus fasciatus, (193, 201, 208, 212, 214, 222, 239, 231).

V, 5. Tamarack Swamp.
Stenobothrus curtipennis, (99 A.).
Mecostethus lineatus, (91 A.).
Melanoplus extremus, (99 A.).

V, 9. Outlet to Siskowit Lake.
Hippiscus tuberculatus, (215).
Melanoplus alaskanus, (215).
Melanoplus fasciatus, (215).
Circotettix verruculatus, (215).

V, 11, Tamarack-Spruce Swamp.
Mecostethus lineatus, (136 A.).
Melanoplus alaskanus, (136 A., 216).
Melanoplus extremus, (136 A.).

I, '04. Clearing on the Shore of Washington Harbor.
Stenobothrus curtipennis, (154 A.).
Chloealtis abdominalis, (154 A.).
Chloealtis conspersa, (154 A.).
Mecostethus lineatus, (154 A.).
Camnula pellucida, (154 A.).
Melanoplus alaskanus, (154 A.).
Melanoplus sp. indet. ♀.

III, '04. Trail along the Top of Greenstone Range.
Melanoplus fasciatus, (143 A.).

VIII, '04. Western End of Siskowit Bay.
Stenobothrus curtipennis, (232).

NEUROPTEROID INSECTS FROM ISLE ROYALE, MICHIGAN.

DR. JAMES G. NEEDHAM, CORNELL UNIVERSITY.

A small but interesting collection of aquatic larvae of dragonflies, stoneflies and mayflies was obtained from Isle Royale, and the fine stonefly, *Pteronarcys dorsata* Say, from the Northern Peninsula. Among the dragonfly larvae were two that are hitherto undescribed, a species of *Sympetrum* too immature for description, and the cast skins and the young larva of a species of *Somatochlora,* described below. The list is as follows:

Odonata.

1. *Anax junius* Drury. A young larva from Isle Royale was collected on August 14 (No. 120 A) in a rock pool on the beach (V, 2); and another on July 29 at Summer Lake (III, 5).

2. *Aeschna* sp.? perhaps *constricta* Say. Represented by both cast skins and nymphs from Sumner Lake (III, 5), Nos. 170, 221, 72 A, 77 A, 78 A, 79 A; a rock pool on the beach (V, 2) on August 14; in the stomach of a duckling loon (*Gavia imber*) from Siskowit Lake (V, 6) August 10, No. 108 A; and from the margin of a swamp (V, 11) on August 16 (No. 126 A).

3. *Aeschna* sp? A second species, represented by a single young larva, was taken in a rock pool (V, 2) on August 14 (No. 120 A). It has lateral spines on segments 5-9 of the abdomen, that of 5 (usually absent) being very small.

4. *Somatochlora* sp? Perhaps *S. forcipata* Selys. (This suggestion as to the species is based solely on the fact that this species is known to occur commonly at Duluth, Minn.). A single young nymph in alcohol, July 26, from the head of Rock Harbor, No. 162; and a cast skin (No. 89) from Rock Harbor (III, 1) July 14, 1905. Being new to science, a description drawn from the cast skin is herewith offered.

Length 23 mm., abdomen 13 mm., hind femur 7 mm., width of head 6 mm., of abdomen 7 mm.

Body stout, hairy on all margins. Antennae very hairy, and also the legs, especially the tibiae externally. Head with a ruff of stiff rough recurved hairs overspreading the abruptly narrowed hind angles. Labium stout and wide, its hinge reaching posteriorly well between the bases of the fore legs. Median lobe prominently angulate in the middle; mental setae about thirteen each side, the outermost eight of these in a close-set uniform series; some of the smaller inner ones more or less out of line. Lateral setae eight; hook small, hardly longer than the setae, but much stouter; teeth crenulately recurved and densely spinulose margined.

The wing cases reach posteriorly to the tip of the 6th abdominal segment. Dorsal hooks on abdominal segments 3-9, beginning with a mere

rudiment on the third and regularly increasing in size backward to the ninth, where somewhat surpassing the level of the tip of the 10th segment; they are spinelike on segments 4-6, but somewhat laterally flattened and distinctly decurved at the tip on segments 7-9. Lateral spines on segments 7 and 8 straight and sharp, directed straight posteriorly, at base very slightly angulate with the lateral margins of their segments, that of the 9th segment about two-thirds as long as its segment and about twice as large as that of the 8th segment. The margins of all the abdominal segments are hairy, especially posteriorly, and there is a dense fringe across the ventral spical border of the 9th segment. The superior appendage is slightly shorter than the inferiors: these are triangular and sharp pointed; the laterals equal the superior in length, and are stout and cylindric, and abruptly pointed.

The larvae of the four American species of *Somatochlora* now known may be distinguished as follows:—

1. Lateral setae of the labium eight: lateral spine of the 9th abdominal segment more than half as long as its segment, and the dorsal hook of that segment larger than its predecessors. *S. forcipata*, supposition.

   Lateral setae of the labium seven: lateral spine of the 9th abdominal segment less than half as long as its segment, and the dorsal hook of that segment not larger, usually smaller, than some of its predecessors ....2.

2. Abdomen less than one-fourth longer than wide: lateral spines of the abdomen, short and broad, equilateral triangles. *S. tenebrosa*, supposition....................................3.

   Abdomen more than one-half longer than broad: Lateral spines of the abdomen longer than more acute........................

3. Dorsal hooks of the abdomen of equal size on segments 6-9.

   Dorsal hooks largest on the 7th and 8th segments, that of the 9th segment smaller ....*S. linearis*.

5. *Cordulia shurtleffi* Scudder. This fine species is apparently common on Isle Royale, being represented by nymphs, Nos. 79 A, from Sumner Lake (III, 5), July 29; No. 120 A. from a rock pool on beach (V, 2) on August 14; and No. 126 A. from a swamp (V, II) on August 16.

6. *Celithemis eponina* Hagen. Two large and four small larvae. From a rock pool (V, 2) on August 14, No. 120 A.

7. *Leucorhinia intacta* Hagen. A number of larvae in bad condition, apparently this species, on July 29, No. 78 A, 79 A, from the sedge zone of Sumner Lake (III, 5).

8. *Enallagma* sp.? A number of broken larvae: Sumner Lake (III, 5), July 29, Nos. 79 A and 126 A; and a rock pool on beach (V, 2) on August 14, (No. 120 A); also from a swamp (V, 11) on August 16 (No. 126 A).

Plecoptera.

1. *Arsapnia vernalis* Newman. A number of specimens of both sexes, Nos. 24, 46, and 80 (I, 1), July 6, 11, and 14. Very abundant upon the cliff at the shore.

2. *Isopteryx cydippa* Newman. One specimen from the balsam-birch forest (V, 4), on August 14 (G. 236.)

Pteronarcys dorsata Say. A few larvae from Otter River, in Baraga County Michigan, collected by A. G. Ruthven, No. 30791, U. of M. Museum.

Ephemerida.

1. *Heptagenia* sp.? One pinned female subimago from Isle Royale in August, wholly undeterminable; another specimen from Tobin Harbor on July 20.
2. *Siphlurus* sp.? probably *S. alternata* Say. A larva from the sedge zone of Sumner Lake (III, 5) No. 78 A, on July 29.

Neuroptera.

1. *Sialis infumata* Walker. One larva and one adult were taken on July 26, by H. A. Gleason, (No. 160) near the head of Rock Harbor (III, 3).

DIPTERA OF THE 1905 UNIVERSITY MUSEUM EXPEDITION TO ISLE ROYALE.

PROFESSOR JAMES S. HINE, OHIO STATE UNIVERSITY.

Much interest always attaches to a collection of insects from northern regions and when Mr. Chas. C. Adams wrote and asked me to work up the Diptera of the 1905 Isle Royale Expedition, I gladly accepted. The collection is a small one and includes a number of common and widely distributed species, but on the other hand it also includes several species of special interest. Most of the specimens were collected by Dr. H. A. Gleason, but he was aided by Mr. B. F. Savery.

As the locality is not so far from midway between the East and the West the question naturally arises as to whether the eastern or the western species predominate in the makeup of the fauna. This matter is the more interesting to me for the reason that lately I have studied a collection of Diptera from New England and also one from British Columbia. After some study of species of Diptera from boreal regions I am convinced that there is not the difference in the eastern and western faunas in the North that there is in the South. There are a number of species in the collection that are common to New England and British Columbia, but there are others that so far are not proven to have such a wide range, and it is with the latter that most interest attaches in the consideration of our question.

If the *Tabanidae* are considered we find that three species may be said to be exclusively eastern and one exclusively western, while six are distributed entirely across the continent.

In the family *Syrphidae* are seven species that may be considered exclusively eastern, and twelve species that reach clear across the continent, but not a single one that is exclusively western.

In the *Stratiomyidae* the single species is eastern. So far as I can find Isle Royale is the farthest west the species has been taken.

In the *Bombyliidae* one species is western, and the other reaches across the continent.

In the *Therevidae* the single species is western, Montreal being the farthest east that specimens have been taken.

In the *Asilidae* two species are eastern and one is western. The western species however is hardly typical.

In the remaining families are several species that are exclusively eastern and several that reach clear across the continent, but none that are exclusively western. To sum up I find four western species and more than a dozen eastern, while there are about thirty that occur from the Atlantic to the Pacific. Therefore, although there are many species common to Isle Royale and British Columbia, the following show that the general complection of the Isle Royale Dipterous fauna favors that of eastern rather than that of western North America.

Family *Culicidae.*

1. *Culex pipiens* Linn. The rain barrel Mosquito was taken July 11, (Station I, Sub. 1) and August 3, (V, 3). This is the common mosquito that breeds in receptacles of standing water and small pools generally, and widely distributed in this country and in Europe, having been described under various names. I hesitated somewhat in giving the specimens a specific name for the reason that they were dropped into alcohol when they were collected and lost many of their scales before they reached me.

Family *Simuliidae.*

2. *Simulium venustum* Say. Black Fly. Taken July 14 (I, 5) and July 28, (III, 5). In Ohio I have found the larvae of this species clinging to rocks in swift flowing brooks and at the outlet of a small artificial lake where the water passed through an iron pipe and dropped a foot or two on to rubbish and stones. This minature waterfall seemed to furnish ideal breeding grounds for the species, for the larvae were there in abundance and the adults were flying about in swarms. The type locality for the species is along the Ohio River near Cincinnati, but it has been identified from a number of states and from Canada. It is a matter of interest to know that the species is a member of the genus with the well known and destructive Buffalo Gnat.

Family *Stratiomyidae.*

3. *Stratiomyia badia* Walker. Judging from the large number of specimens taken the species must have been common from July 17-31. All specimens were taken at the Light-house clearing (I, 7). At Sandusky the species appears in numbers on flowers of White Sweet-clover and milkweeds, and specimens are often seen with the pollen-masses of the latter plant clinging to their feet. The Isle Royale specimens are typical in coloration but are slightly larger on an average than other specimens I have seen. The type locality is New Hampshire but its range is known to extend over a large part of northeastern North America.

Family *Tabanidae.*

4. *Chrysops carbonarius* Walker. Specimens were taken along the McCargoe Cove trail and at the head of Rock Harbor (III, 3), July 11-14. This is usually a northern species but has been taken on the eastern coast of the United States as far south as North Carolina. It belongs to the group without an apical spot and is closely related to *mitis*, the species next considered, and from which it is separated by the presence of a hyaline spot at the base of the fifth posterior cell. In these specimens this spot is very small, sometimes making it difficult to say to which species they really belong. As a usual thing specimens of *carbonarius* are noticeably smaller than specimens of *mitis*.

5. *Chrysops mitis* Osten Sacken. A number of specimens taken along the McCargoe Cove Trail, July 11, are of this species. As stated above the difference between this species and the former is not always ap-

parent, but the specimens with the fifth posterior cell uniformly infuscated at its base are usually decidedly larger than the others. This is quite noticeably in the Isle Royale specimens. The type locality for the species is the Lake Superior region, therefore these specimens should be and are very nearly typical. Specimens of *carbonarius* from farther east usually have a distinct hyaline spot at the base of the fifth posterior cell and therefore are easily known.

6. *Chrysops frigidus* Osten Sacken. A single specimen taken August 7, by B. F. Savery (V, 3) answers the description of this species very well. Here the abdomen is variable in coloration in a series of specimens, but the wing markings are nearly constant. I have never observed or heard of the species being so abundant and troublesome as other members of the genus. Type locality Great Slave Lake and other northern regions, but it is now known from as far south as Ohio and New Jersey.

Tabanus affinis Kirby. Taken July 2, on Mackinaw Island, Michigan. A species with hairy eyes, measuring nearly 20 millimeters in length, the abdomen is broadly red on the sides and the palpi are long and slender. The type locality is Boreal America and the species may be expected anywhere from Maine to British Columbia. This specimen is typical for the species.

7. *Tabanus epistatus* Osten Sacken. Three specimens taken at Light-house clearing (I,7) July 8, 11 and 31. Similar to the last in coloration and general appearance, but smaller and the palpi are robust. Type locality Hudson Bay Territory, but now known to be widely distributed in northern United States and Canada south to Ohio and New Jersey.

8. *Tabanus lasiophthalmus* Macquart. A single specimen taken at Rock Harbor, in July, by Adams. The eyes are hairy, the abdomen is red on the sides and the size is near that of *epistatus*. The cross-veins are margined with fuscous making the wings appear spotted, a character which serves to separate it from *epistatus* and most other northern species with hairy eyes. Type locality Carolina, but it is distributed over northeastern North America south to Georgia and west to Illinois.

9. *Tabanus nivosus* Osten Sacken. Several specimens taken at Light-house clearing (I, 7) July 11, 26 and 28; (V, 3) August 7 and 9. Length about 15 millimeters with a row of large white blotches or spots on each side of the abdomen; wings clear hyaline; general color blackish. Type locality New Jersey, and known from New York and Ohio.

10. *Tabanus* sp. Specimens taken at Light-house clearing (I, 7), July 18 and 22. This, I take it, is a distinct species but it may be one of Walker's obscure forms and I hestitate to name it specifically until more material is available. The size is near that of *nivosus*, but the general color is reddish, and the white markings on the sides of the abdomen are not so conspicuous. There are a number of other characters which distinguish it.

11. *Tabanus illotus* Osten Sacken. Specimens taken at Light-house clearing (I, 7), July 7, 11 and 25; and (III, 3), July 14, and August 5. Eyes hairy, abdomen with a row of white spots on each side, wings

with the front part of the basal half clouded with fuscous, but otherwise hyaline. The species is near the size of *nivosus* and appears much like that species. Type locality Hudson Bay Region, but at the present time known from Alaska and various parts of the British Possessions. Specimens from Isle Royale have the white spots on the sides of the abdomen larger than in some specimens I have observed.

12. *Tabanus insuetus* Osten Sacken. A single specimen taken by B. F. Savery August 9, (V, 3). This is the only species known from the western states, with the hairy eyes and ocelligerous tubercle absent and therefore falls in the genus *Atylotus* of some authors. Type locality Weber Lake, California. Now known from Alaska, British Columbia and several of the northwestern states.

13. *Tabanus astutus* Osten Sacken. (?) Several specimens taken at Light-house clearing (I, 7) July 26 and 28, and (V, 3) August 7 and 15, by B. F. Savery. These specimens come nearer agreeing with *astutus* than any other species I know, but there are some points in which they do not agree and for that reason I have named them *astutus* with a question. Walker described a number of species from the far north that have never been identified since. It is therefore with much interest that I receive such collections as the present. Although a number of species have a wide north and south distribution in boreal regions every collection from the north is apt to contain something of interest.

Family *Bombiliidae.*

14. *Anthrax morio* Linn. Two specimens taken at Light-house clearing (I, 7), July 11 and 26. *Anthrax seminigra* and *morio* are believed to be synonyms. The species is common to Europe and North America and is distributed in the latter country from Maine to British Columbia. Nearly the basal two-thirds of the wing is black, the remainder hyaline. The outer margin of the black is irregular and begins on the costa near the apex and proceeds obliquely, gradually nearing the base.

15. *Anthrax fulviana* Say. A single specimen taken July 26, (III, 3). The whole body of this insect is clothed with dense yellow pile, the legs are black and the wings hyaline with costal margin and narrow, base black. Type locality Pembina, Minnesota, and besides it has been taken in New Mexico, Washington and British Columbia.

Family *Therevidae.*

16. *Thereva frontalis* Say. Two specimens taken at Light-house clearing (I, 7) July 29, and (V, 3) August 9. Type locality Northwest Territory and specimens are at hand from Montreal, Colorado and British Columbia. The Isle Royale specimens are rather larger in size than other specimens I have seen but agree closely in coloration with Colorado examples. Those at hand from British Columbia are slightly more brownish, but the thoracic and abdominal markings are of the same form and extent in all.

Family *Asilidae.*

17. *Cyrtopogon chrysopogon* Loew. Taken at Light-house clearing (I, 7), July 6 and 10. Type locality Massachusetts. Known from Montreal, Quebec, New Jersey, New York and Florida. This record extends the westward range of the species considerably. It is black with the beard straw-yellow and the bases of all the tibiae red.

18. *Dasyllis astur* Osten Sacken. Taken at Light-house clearing (I, 7), July 7. The two specimens that I include under this name do not fully agree with the original description of the species but are nearer it than to *posticata*, and as Osten Sacken indicates certain variations in his description the specimens are given this name. In typical *astur* from British Columbia the pile on the anterior dorsum of the thorax is largely black and that on the tibiae yellow. In the Isle Royale specimens the pile on the anterior dorsum of the thorax is all yellow and that on the tibiae is black. Osten Sacken observed that specimens of *astur* taken at low altitudes had the pile on the tibiae black, and as the size agrees I believe it proper to place the specimens in this way. Type locality California, but otherwise known from Oregon, Washington and British Columbia.

19. *Asilus annulatus* Williston. Three specimens taken August 5 (V, 3). Known from northeastern North America, as far west as Kansas. The specimens appear to be typical for the species.

Family *Dolichopodidae.*

20. *Hydrophorus philombrius* Wheeler. A number of specimens taken July 11 (I, 1). I suspect there are plenty of species of this family in the Isle Royale locality but this is the only one included in the collection sent for study. The type locality is Milwaukee County, Wisconsin, and it is also recorded from Texas. These specimens are typical, agreeing in detail with the original description and figure.

Family *Syrphidae.*

21. *Chrysotoxum ventricosum* Loew. Specimens taken July 7, at Light-house clearing (I, 7). The family *Syrphidae* is a most attractive family of flies and the genus to which this species belongs is one of its finest groups. The various species are mostly found in northern regions or at high altitudes, and are easily recognized by the oblique yellow abdominal markings and elongate antennae. This one is the largest American species of the genus and was first described from specimens taken in the District of Columbia. It is now known from New Jersey, Canada and Arizona.

22. *Pyrophaena granditarsus* Forster. A female specimen taken July 28, at Light-house clearing (I, 7). This is the same species that formerly passed under the specific name *ocymi*. It is common to Europe and North America and in the latter country is distributed from New England to British Columbia. The two sexes are very different in appearance and to some extent in structure, and it is from the front tarsi of the male that its specific name is derived.

23. *Platychirus peltatus* Meigen. Taken July 25, (II, 1). Common

to Europe and North America. Widely distributed in northern North America from New England to British Columbia and Alaska.

24. *Platychirus hyperboreus* Staeger. Taken at Light-house clearing (I, 7) July 23 and 26. Type locality Greenland but widely distributed in North America. As with most species of the genus only the males can be identified satisfactorily by the known characters.

25. *Melanostoma angustatum* Williston. Specimens taken July 23 and 26, at Light-house clearing (I, 7). Type locality, state of Washington. Known also from the White Mountains and British Columbia.

26. *Syrphus americanus* Wiedemann. One specimen taken July 22, at Light-house clearing (I, 7). The species is abundant and somewhat variable in coloration and is distributed over nearly the whole United States and Canada. The larvae have been observed feeding on the grain Aphis.

27. *Syrphus diversipes* Macquart. Specimens taken August 4 and 7, (V, 3). Type locality Newfoundland. Distributed from New York to British Columbia and Alaska, reaching as far south as southern Ohio.

28. *Syrphus genualis* Williston. Taken July 24, at Light-house clearing (I, 7), July 25, (II, 1). Type locality New Hampshire and recently reported from Beulah, New Mexico.

29. *Syrphus ribesii* Linn. Specimens taken July 24 and 26 at Light-house clearing (I, 7). Common to Europe and North America. This is one of the most common members of the family and is almost sure to be included in local lists of Diptera as it is distributed over nearly the whole of North America. The larvae are of importance as they feed on various species of plant lice. One often sees a colony of plant lice with one of the syrphid larvae in the midst of them, and he cannot help becoming interested if he observes for a short time and endeavors to count the number of plant lice a larva is able to devour in a given time under favorable conditions.

30. *Sphaerophoria cylindrica* Say. Specimens taken July 25, 26, and 28 at Light-house clearing (I, 7) and July 25, (II, 1). Type locality Pennsylvania. Common over a wide range and included in many local lists. The larvae are reported as feeding on the grain Aphis and on that account the species is of interest to the economic entomologist. The sexes are quite different from one another and one is not likely to associate them on first acquaintance.

31. *Eristalis dimidiatus* Wiedemann. Specimens taken July 22, 24, 25 and 26 at Light-house clearing (I, 7), August 4 (V, 3) and July 25 (II, 1). About 40 specimens of this species were procured indicating that it is as common at Isle Royale as at other places. The larvae of the various species of *Eristalis* are what are known as rat-tailed larvae and are found in shallow water in swampy places or at the outlet of sewers and drains. Each larva is furnished with a posterior appendage which can be lengthened and shortened at will and which contains the posterior parts of the tracheal trunks. At the free end of the appendage are the two posterior spiracles which are kept at the surface of the water. Thus the larva is fitted so it can remain beneath the water and yet get the necessary air for carrying on respiration. The adults are common around flowers in autumn, sometimes several species visiting the same patch of asters or goldenrods as the case may be. *E. dimi-*

diatus is found all over eastern North America from Florida to Canada and west to Kansas.

32. *Eristalis bastardii* Macquart. Specimens taken August 4 (V, 3). I have observed this species at midday when the sun was shining, flying actively over water and have taken them in numbers at such times with a net. It is common over the greater part of northeastern North America, being found as far south as the District of Columbia.

33. *Helophilus similis* Loew. Specimens taken July 26 and 28 at Light-house clearing (I, 7). The members of this genus are peculiar in that the eyes are separated in the male as well as the female. This species is often taken in early spring from the blossoms of willow and other early flowering plants. The type locality is Georgia but it appears to be more common northward where its range extends from the Atlantic to the Pacific.

34. *Mallota cimbiciformis* Fallen. Specimens taken July 23 and 26 at Light-house clearing (I, 7). Common to Europe and North America and widely distributed over the eastern part of the latter country. The species has a resemblance to certain species of *Eristalis,* but the greatly thickened hind femora are distinctive.

35. *Xylota curvipes* Loew. One specimen taken July 26, at Light-house clearing (I, 7). The genus *Xylota* contains upwards of 40 North American species which in the main are reasonably easy to separate, and for that reason it is an attractive group. Various species are often observed resting on logs in damp places or that lie across small streams. In many the abdomen is distinctly elongated and the hind femora are swollen. *X. curvipes* is common to Europe and North America, being most often taken in northern latitudes.

36. *Xylota fraudulosa* Loew. One specimen taken August 12 (V, 3). Type locality Illinois, but known in northern North America from New England to Washington reaching south to Ohio and Nebraska.

37. *Xylota pigra* Fabr. One specimen taken July 22 at Light-house clearing (I, 7). Common to Europe and North America and generally distributed over the United States and Canada. The adult has been reared from a larva taken from under the bark of a pine tree.

38. *Temnostoma aequalis* Loew. Specimens taken July 17, 22, 23, 24, 26 at Light-house clearing (I, 7) and July 25 (II, 1). This fly has somewhat the appearance of the common bald-faced hornet and one usually thinks the second time before taking it in his hand. In Ohio various species of the genus are to be found around rotten logs where the females oviposit and the larvae pass their lives as such. Type locality, English River, Hudson Bay Region. Otherwise known from New England and Colorado. The Isle Royale specimens vary slightly in abdominal and thoracic markings but on the whole agree very well with the original description.

39. *Temnostoma bombylans* Fabr. One specimen taken July 17, at Light-house clearing (I, 7). Common to Europe and North America and widely distributed in the latter country, having been taken as far south as southern Ohio.

Family *Tachinidae.*

40. *Pelcteria robusta* Wiedemann. One specimen taken July 26 at Light-house clearing (I, 7). This species is reported as occuring from

Argentina to Canada and from the Atlantic to the Pacific. Wiedemann's types were taken in South America. The Isle Royale specimen has less red at the tip of the abdomen than most Ohio specimens.

The family *Tachinidae* contains a large number of species and nearly all of them are of more or less interest to the economic entomologist on account of their parasitic habits. Many injurious insects have one or more Tachinid parasites which aid in holding them in check.

41. *Echinomyia algens* Wiedemann. Two specimens taken July 14 (III, 3) and July 26 at Light-house clearing (I, 7). The types were taken in North America, but the exact locality is not given. Recent writers have reported the species from many points in Mexico and northward. It is said to be parasitic on the larvae of the moth, *Hadena lignicolor* Guenée.

Family *Sarcophagidae.*

42. *Sarcophaga sarraceniae* Riley. Flesh Fly. A specimen taken July 11 at Light-house clearing (I, 7). This is our common flesh fly, and is an important scavenger. Type locality Missouri. The species of *Sarcophaga* are not well understood in America and it may be that this is a synonym. However the name is included in many local lists of Diptera which indicates a wide range for the species.

43. *Lucilia caesar* Linn. Carrion Fly. Four specimens taken July 25 (II, 1), July 26 at Light-house clearing (I, 7) and August 5 (V, 3). Known from Europe and America. A very common carrion fly everywhere. Along the shores of the Great Lakes its larvae feed largely upon the carcases of fishes cast on the beach by the waves.

44. *Callophora viridescens* Desv. Blow Fly. Three specimens taken July 25 (II, 3) and August 7 (V, 3). This is one of the common blow flies and is widely distributed in Europe and America.

45. *Cynomyia cadaverina* Desv. Two specimens taken July 8 (I, 1). Carolina is the type locality but the species is found in most localities in the United States and Canada.

46. *Phormia terraenovae* Desv. A specimen taken August 4 (V, 3). Type locality Newfoundland. Generally distributed over North America, especially northward.

Family *Muscidae.*

47. *Musca domestica* Linn. House Fly. A specimen taken August 7 (V, 3). This species needs no particular comment here. It is found in nearly all parts of the world and has lately been proven to be connected with the transmission of typhoid fever.

Family *Anthomyidae.*

48. *Hyetodesia serva* Meigen. Five specimens taken July 11, 23 and 24 at Light-house clearing (I, 7) and August 4 (V, 3). This European species has been reported for America, but its distribution is not well understood. I have compared these specimens carefully with Schiner's description and find that they agree well, but as the group is very rich in species their determination is not always an easy matter.

Family *Sciomyzidae.*

49. *Tetanocera plebeia* Loew. A specimen taken July 26 at Lighthouse clearing (I, 7). Type locality Middle States. Specimens are at hand from British Columbia and other localities. The members of this genus are often common in marshy and damp places.

50. *Sepedon pusillus* Loew. Two specimens taken in a swamp in Cassandra and Sedge Zone (V, 2), by Max M. Peet. Type locality Middle States. Known from Ohio, New Jersey and White Mountains, New Hampshire. The various species of this genus are usually found in swamps where they may be observed flying over water.

ANNOTATED LIST OF ISLE ROYALE HYMENOPTERA.

E. G. TITUS, ENTOMOLOGIST, UTAH AGRICULTURAL EXPERIMENT STATION.

The determinations in this group were made in Washington at the U. S. National Museum, Mr. J. C. Crawford and myself working over most of the material together. Mr. Theodore Pergande, Bureau of Entomology, determined the two species of ants represented in the collection. The general collection of ants are reported upon elsewhere by Dr. W. M. Wheeler. Mr. W. F. Fiske, at that time in the Forest-Insect section of the Bureau of Entomology, very kindly determined the Ichneumons and Siricids, both of which groups he had been working with for several years. At the time the determinations were made the writer had no expectation of writing up the notes or he would have doubtless been able to add considerable to their value by making further notes on the specimens retained at the National Museum.

Bombidae.

Bombus terricola Kby. (Det. Crawford.) Three on flowers of *Opulaster* (II, 1) (14): about camp at Rock Harbor several specimens (133, 166 three, 179, 191) and one specimen (222) around camp at Siskowit Bay.

Geographic Range: Originally described from Canada; Kirby, 1837. Also reported by Provancher from region around Montreal and by other authors from various localities in Northern United States east of the Rocky mountains and as far south as Colorado. I have seen specimens from Massachusetts, New York, Illinois, Kansas and Colorado.

Bombus consimilis Cress. (Det. Crawford.) Two were taken around camp at Rock Harbor (36, 45).

Geographic Range: Described from New York, Cresson 1864, p. 41 and reported by Packard, 1864, p. 112.

Bombus sp. One flying over beach at end of Conglomerate bay (31); one on flowers of *D. trifida* on a jack pine ridge (23); and two about camp at Rock Harbor (A. 5, 98). These all seem to represent one species but neither Mr. Crawford or myself care to name it in the present unsettled condition of the group.

Psithyrus latitarsus Morrill (Det. Crawford.) Two around camp clearing at Rock Harbor (A 36, 45).

Geographic range: Desc. from Montana by Morril 1903, p. 224.

Megachilidae.

Monumetha albifrons Kby. (Det. Titus.) One specimen flying over ridges near Conglomerate bay, (68).

Geographic range: Desc. by Kirby 1837, p. 270 from "Lat. 65°"; again by Cresson 1864, p. 387, 388, as three separate new species from Colorado, Pikes Peak, and Slave Lake. It probably occurs over all the region from the Mackenzie river and Upper Hudson bay to the lower

Rocky Mts. areas in New Mexico and westward to the Pacific. (Titus 1906, p. 158, Cockerell 1906) (1 and 2). Nothing is known of its breeding habits. I have specimens from eastern Canada and New England but have seen none from south of New York along the Atlantic region. There are mites on the Isle Royale specimens.

Xanthosarus melanophæa Smith. (Det. Titus). Taken on jack pine ridge (108); about camp at Rock Harbor (133, 166 eleven) and on flowers of *Campanula rotundifolia* in clearing at Siskowit Bay (148, 202).

Geographic range: Described from British America, Smith 1853, p. 91 and known to occur throughout the region of southern Canada, New England, New York, and in northern United States to the Pacific coast and in British Columbia. This and the following species are leaf-cutters working especially on the leaves of Rosa spp., the pieces clipped out are used in lining their nests which are usually made in old logs or dead trees, the female often utilizing the abandoned boring of some other insect. The little rolls are often found when splitting logs or wood in the fall or winter.

Xanthosarus latimanus Say. (Det. Titus). Very frequently taken about the camp clearings at Rock Harbor and Siskowit Bay (38, 49, 68, 133, 137, 153, 179, 231); also at sand beaches at head of Conglomerate bay (31); on jack pine ridges (68, 1-8); near Neutson's resort (121); on flowers of *Opulaster* (148); and on flowers of *Campanula rotundifolia* (202).

Geographic range: Described from "Arkansas" by Say 1823, p. 81, which may mean any where from Missouri to Colorado. It is one of the most common species in the United States and Canada, occurring from coast to coast and from the Gulf northward.

Anthemois sp. near *infragilis* Cresson (Det. Titus). This specimen was taken around camp at Rock Harbor (86). While it bears a close resemblance to *A. infragilis* there are sufficient differences to make it a good species and probably new. *A. infragilis* was described from New York and probably occurs in the Isle Royale region, since I have seen specimens from Canada (Titus 1906, p. 152).

Stelidae.

Cœlioxys moesta Cresson. (Det. Titus). One on flowers of *Campanula rotundifolia* in clearing at Siskowit Bay (202) (V, 2).

Geographic range: Described from Connecticut, Cresson, 1864, p. 403; reported by Provancher, 1882, p. 241, 1883, p. 725 as *tristis*, from Canada. Occurs westward to Colorado, New Mexico and probably Utah.

Chelynia nitida Cresson. (Det. Titus). One specimen about camp at Rock Harbor (26).

Geographic Range: Desc. from New York by Cresson, 1878, as a *Stelis* and from Canada by Provancher, 1888, p. 322 as *Chelnia labiata* and in Panurgidae. Ashmead, 1896, p. 283, erected the genus *Melanostelis* for his species *betheli*, which is congeneric with *nitida* (Titus, 1906, p. 161).

Andrenidae.

Halictus lerouxii Lepeletier. (Det. Crawford). One specimen about camp at Rock Harbor (133).

Geographic range: Described by Lepeletier 1841, p. 272 from "Am. Boreal." Occurs at least as far west as Illinois, Robertson, 1893, p. 146.

Halictus versans Lovell. (Det. Crawford). Five specimens on flowers of *Physocarpus* in Ransom clearing (II, 1), (148).

Geographic range: Described from Maine by Lovell.

Prosopidae.

Prosopis basalis Smith. (Det. Crawford and Titus). One about clearing at Rock Harbor (166).

Geographic range: Described from Hudson's Bay by Smith, 1853, p. 23 and occurs from the upper Atlantic coast to at least the mountains of Colorado.

Prosopis species. (Det. Crawford). On flowers of *Opulaster* (V, 2) behind camp at Siskowit Bay (203); in camp clearing at same place (212) and two unmarked specimens. There may be two species involved here but we were unable to specifically determine them. The species of the genus breed in stems of small plants.

Crabronidae.

Crabro singularis Smith. (Det. Crawford). One specimen on sand beach on a jack pine ridge near Conglomerate bay, (108).

Geographic range: "Canada and United States."

Solenius sp. (Det. Titus and Crawford). One specimen about camp at Rock Harbor, (179).

Pemphredonidae.

Diodontus adamsi n. sp. Titus (Det. Titus and Crawford). On sand beach with *Ammophila* at end of Conglomerate bay (31). Notes on *Ammophila* will apply to this species.

♀ Leng h 7.1 mm. Black, with scattered silvery pubescence, especially abundant on face; clypeus projecting, with two sharp teeth wide at the base, tips of mandibles reddish, palpi brown; tegulae brown, yellow in front; wings slightly infuscated; tibiae and tarsi reddish brown.

Sphegidae.

Ammophila sp. (Det. T. & C.). Three on sand beaches at head of Conglomerate bay (31); one near Tonkin bay (41); and one about camp at Rock Harbor (133). The normal habitat of this species of sand-wasp is on the sand beaches. They fly rapidly about at a height of 3-15 centimeters over the sand or gravel, alighting only on the sand. This group all store their nests with caterpillars, the holes being usually in quite hard ground. They are very skillful in removing or covering up all traces of the place where they have worked, often going to much more labor than the occasion would seem to require. Peckham and Peckham, 1898, pp. 6-32, have a very interesting chapter on this subject.

Psammophila sp. (Det. T. & C.). One specimen from rock clearing near outlet of Siskowit lake (V, 9) (215).

Ceropalidae.

Entypus americanus Pal-Beauv. (Det. T. & C.). One specimen (235) captured with a specimen of *Lycosa kochi* Keys. (Det. Banks). The wasp was backing over the ground, dragging the spider, at brief intervals it dropped its prey and ran rapidly back and forth looking for its hole. It apparently had a general idea of the direction in which the nest lay but had to walk right to it in order to be certain of its location. Even a couple of centimeters was not close enough. Having found the nest the wasp searched in the same way for the spider and was backing away with it in a direct line for the hole when both were captured.

Geographic range: Della Torre gives "United States." It was described by Palisot-Beauvois, 1811, p. 117. Peckham and Peckham, 1898, pp. 125-166, describe the labors of several species belonging to this group and call them "The Spider Ravishers."

Vespidae.

Vespa diabolica Saussure. (Det. T. & C.). One specimen about camp clearing at Rock Harbor (166). Described by Saussure, 1853, p. 138. Occurs fairly common throughout the eastern United States and Canada. There have been many errors in determining species of this group so that one can hardly state the distribution of any species.

Euminidae.

Ancistrocerus capra Sauss. (Det. T. & C.). One taken about camp at Rock Harbor (133).

Geographic range: Saussure 1857, p. 273. Known to occur in northern United States and eastern Canada.

Ancistrocerus pertinax Sauss. (Det. T. & C.). Two on flowers of *Heracleum lanatum* in camp clearing at Rock Harbor (105). This species may be a true *Odynerus*. All of this group are predaceous and these probably store their nests with caterpillars. Their habits are varied, some boring in one plant or substance and others using old burrows.

Geographic range: Saussure, 1856, p. 216. Known from northern and eastern United States and Canada.

Eumenes sp. (Det. T. & C.). One in Cladonia clearing behind camp at Siskowit Bay (201). This genus are the so-called "jug-makers" or "mason-wasps" and store their nests with small caterpillars.

Formicidae.

Formica sp. (Det. Pergande). One specimen in camp clearing at Siskowit Bay (231).

Camponotus pennsylvanicus Degeer. (Det. Pergande). One from Station IV, 1 (130), another found running over smooth sand bleach at head of Conglomerate bay (31); one at camp at Rock Harbor (104)

and others at Siskowit Bay camp (212, 222 eleven, and 232). A very common species throughout eastern United States and Canada.

Chrysididae.

Chrysogona verticalis Patton. (Det. T. & C.). One specimen about camp clearing Siskowit Bay (239).

Geographic range: Described by Patton 1879, p. 67, and afterward noted by Aaron 1885, p. 226, from California and Provancher 1887, p. 215, from Canada.

Evaniidae.

Gasteruption incertus Cresson. (Det. Fiske). One at camp at Siskowit Bay (239). Mr. Fiske placed this in *Foenus* which Ashmead makes a synonyn of *Gasteruption.*

Geographic range: "Canada, Colorado" Cresson. All of this genus that have been bred were found parasitic on some species of wasp or bee.

Gasteruption tarsitorius Say. (Det. Fiske). One taken at Siskowit bay camp clearing (A. 152).

Geographic range: Eastern United States and "Canada."

Aulacus rufitarsus Cresson. (Det. Fiske). One at Rock Harbor (133); and others at Siskowit Bay (A. 152, 212 five, 231 two, 239).

Geographic range: "Canada, Colorado" Cresson.

Some of the species in this group are parasitic on Cerambycid larvae.

Ichneumonidae.

Pœmenis sp. (Det. Fiske). One about camp clearing Siskowit Bay (231). Probably a parasite on some wood-boring coleoptera.

Pimpla conquisitor Say. (Det. Fiske). One about camp clearing Rock Harbor (179).

Geographic range: "Canada; U. S." Cresson.

Doubtless parasitic on a Lepidopterous larva.

Ephialtes gigas Walsh. (Det. Fiske). One about camp at Siskowit Bay (153).

Geographic range: Described from Illinois, also reported from Canada.

Rhyssa albomaculata Cresson (Det. Fiske). Taken at Rock Harbor clearing (166), and at Siskowit Bay camp clearing (A. 152, 153, 212 six, 222, 231 two, 239).

Geographic range: "Canada; U. S." Cresson.

Species in this genus have been repeatedly bred from the larva of xylophagous saw-flies such as Urocerus. The ovipositors in some species attain the length of six or more inches, with these they are able to reach the larva of the host and lay their eggs even when the unsuspecting victim is living far inside the trunk of a tree.

Braconidae.

Apanteles sp. (Det. C. & T.). One alcoholic specimen without data. It would be impossible to even superficially determine this from the one specimen.

Gymnoscclus pedalis Cresson (Det. Fiske). All taken around camp clearing Siskowit Bay, (A. 152, 212 six, 222 three, 231, 239 six).

Geographic range: Canada, Eastern U. S.

Parasitic upon some wood-boring Coleoptera.

Melanobracon sp. (Det. Fiske). Two taken at camp clearing Siskowit Bay (212).

Siricidae.

Urocerus flavipennis Kirby. (Det. Fiske). All specimens taken in camp clearing, or near it, at Siskowit Bay (A. 152 four, 153, 91, G. 212 two, 209, 228, 231 three, 239 seven). Usually flying with a moderate velocity about the clearing, keeping at average height of 2-3 feet and not alighting. A few were found climbing up and down trunks of balsam trees in which they deposit their eggs.

Geographic range: Vancouver's Island, Kirby 1882, p. 380. Occurs across the continent.

Urocerus flavicornis Fabricius. (Det. Fiske). All taken in or near Siskowit Bay camp clearing and not differentiated at the time from the previous species (195, 201, 212, 241 two).

Geographic range: British America, Fabricius 1781, p. 418; appears to be a more northern species in its range than *U. flavipennis* though they are often taken in same localities.

Tenthridinidae.

Tenthredo mellina Nort. (Det. MacGillivray). One at Rock Harbor (136), others on flowers of *Opulaster* in camp clearing Siskowit Bay (203) and around camp, same place (208).

Geographic range: Canada and U. S.

Cimbicidae.

Cimbex americana Leach. (Det. T. & C.). Taken in rock clearing near water's edge on north side Conglomerate bay (106); also one larva in alcohol which may belong to this or the next species.

Geographic range: The earliest record for this species is Abbot 1792, plate 61, under the name of *femorata* Linne. Leach described it in 1817, p. 33, and since that time many authors have written upon the species which is rather a common insect throughout most of the regions in North America where willows are found. The larva of this and probably the following species feed on willow leaves.

Cimbex violacea Lepeletier. (Det. T. & C.). July 13. Sta. I, 2 (71 and 55).

Geographic range: Described by Lepeletier 1823, p. 27, from North America and reported by Kirby from British America; also occurs in northern United States.

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THE ANTS OF ISLE ROYALE, MICHIGAN.

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Subfamily *Myrmicinae.*

1. *Myrmica brevinodis* Emery var. *canadensis* Wheeler. Several workers from a single colony: 61 (I, 2) H. A. Gleason. "Found on the dry rock ridges under the mats of bearberry and also excavating nests in the crevices of rocks to a depth of some 8 cm." This is the common variety of the subspecies *brevinodis* at higher elevations in Canada and the Eastern States.

2. *Leptothorax acervorum canadensis* Provancher. Workers from three colonies: 63 (I, 2), (I, 1), 77 (I, 2), H. A. G. "Abundant in *Cladonia* clearings and on rock ridges, running about on the surface and through the thin deposits of soil. The specimens of No. 73 were from the rock pools on the shore just south of Tonkin Bay." This ant, like the preceding, extends its range into the Northern and Eastern States, but it is by no means common. It is abundant, however, at higher elevations (8000-9000 ft.) in the Rocky Mountains and at lower elevations in Nova Scotia.

Subfamily *Dolochoderinae.*

3. *Tapinoma sessile* Say. Workers from a single colony: 132 (V, 2) C. C. Adams, "under *Cladonia.*" This is the only Dolichoderine ant which ascends to high latitudes and elevations. I have found it nesting under stones at altitudes of over 10,000 ft. near Cripple Creek, Colorado, and it is common in the Canadian zone throughout the Rocky Mountains. In the Northeastern States it descends to sea-level.

Subfamily *Camponotinae.*

4. *Lasius niger* L. var. *neoniger* Emery. Workers from five colonies: 20 (I, 5) C. C. A., and 75 (I, 1), 79 (I, 5), 82 (I, 5), 83 (I, 5), H. A. G., "Abundant on the rock ridges and jack pine ridges (I, 2, 5). The nest is always constructed beneath or at the side of a flat or angular stone, at a depth of one decimeter or more. A complicated system of roomy galleries is excavated with passages 1.5-2.5 cm. high by 2-5 cm. broad. This ant was seen to capture and kill a beetle. No. 75 H. A. G. is material from the rock pools." (Gleason).

There are in North America three distinct varieties of the circumboreal *L. niger,* viz., var. *neoniger* Emery, *sitkäensis* Pergande and *americanus* Emery. The first and second have the legs and antennae of the workers and females covered with suberect hairs, and the hairs on the body are also conspicuously abundant. *L. neoniger* is small and black, *sitkäensis* much larger and of a lighter brown or yellowish color. *L.*

americanus is small, like *neoniger,* but brown and has few erect hairs on the body and none on the legs and scapes. It is closely related to the palearctic variety *alienus* Förster, and like this form inhabits warm and rather dry localities. It is the common form of *niger* throughout the Northern States. *L. sitkäensis* occurs in Alaska, Nova Scotia and in the damp alpine meadows of the Rocky Mountains at altitudes between 8000 and 9000 ft. *L. neoniger* occurs in dryer situations at somewhat lower elevations and is occasionally found even near sea-level in isolated colonies in our northern woods. Varieties (hybrids?) intermediate between *neoniger* and *americanus* also occur in these same localities.

5. *Formica sanguinea aserva* Forel. Workers from two colonies: 78 (I, 2), 72 (I, 2) H. A. G. "This is one of the commonest species on the rock ridges, but constructs its nest either in or under decaying wood. On the ridge north of the light house, a nest (72) was made under a rather small rotten stick, and the soil beneath was composed mainly of finely comminuted fragments of the wood. The second colony (78) had constructed a nest in the interior of a large decaying log." (Gleason). This subspecies has been taken hitherto only at Toronto (Forel), on the summit of Mt. Washington (Mrs. A. T. Slosson), among the Litchfield Hills of Connecticut (Wheeler) and in Casco Bay, Maine (Wheeler). It is a decidedly boreal form, approaching the typical palearctic *sanguinea* in size and coloration. There were no slaves accompanying the specimens from Isle Royale, a fact which tends to confirm the conclusions of Forel and myself that this subspecies usually lives in pure colonies.

6. *Formica adamsi* sp. nov. *Worker.* Length 3.5-5mm. Allied to *F. rufa* L. Head, including the mandibles, nearly as broad as long even in the smallest individuals, with straight posterior border, rounded posterior corners, and slightly but distinctly convex sides. Eyes large. Mandibles 7-8 toothed. Clypeus prominently carinate, with broadly rounded anterior border, not produced in the middle. Palpi of moderate length. Antennae slender, scapes nearly straight at the base, funicular joints all distinctly longer than broad, the basal somewhat more slender and longer than the apical joints. Pro- and mesonotum moderately rounded, convex, the latter eliptical and nearly twice as long as broad, the former a little broader than long. Epinotum with subequal base and declivity, the former slightly convex, the latter flattened or slightly concave; the two surfaces in profile passing into each other through a rounded angle. Petiole more than half as broad as the epinotum, in profile with convex anterior and flattened posterior surface and sharp upper border; seen from behind the border is rounded and but feebly or not at all produced upward in the middle. Gaster and legs of the usual shape.

Opaque throughout; only the mandibles, frontal area and sides of the clypeus faintly shining or glossy. Mandibles finely and densely striated. Surface of body densely and indistinctly shagreened.

Hairs and pubescens pale yellow; the latter covering the whole body and appendages, not conspicuous except on the gaster, but even on this region not sufficiently dense to conceal the surface sculpture. Hairs short, sparse and obtuse, in several rows on the gastric segments; on the thorax confined to the upper portions of the pro- and mesonotum, on the head to the clypeus, front and vertex. The hairs on the mandibles

are appressed and pointed, on the palpi short but numerous and conspicuous. Legs naked except for a series of pointed bristles on the flexor surfaces of the tibiae and tarsi and a few blunt hairs on the anterior surfaces of the fore coxae.

Sordid brownish red, the smaller specimens somewhat more yellowish red. Gaster dark brown, except a large spot on the base of the first segment and the anal region, which are reddish yellow. A large spot on the pronotum, one on the mesonotum, much of the posterior portion of the head, the distal halves of the antennal funiculi and in many specimens also the coxae and femora, dark brown or blackish. These dark markings are present in the largest as well as in the smallest workers. Teeth of mandibles black.

Described from numerous specimens taken from a single colony: 115 (I, 6) H. A. G. A dozen workers taken by myself on Pikes Peak, Colorado, near timber line, at an altitude of 10,500 to 11,000 ft. differ from the Isle Royale specimens only in having the frontal area smooth and shining, in having the middle of the petiolar border produced upward as a distinct, blunt point, and in the less extensive infuscation of the head, pro- and mesonotum. These specimens may be regarded as representing a distinct variety, *alpina* var. nov. Both this and the typical *adamsi* may be distinguished from our other North American forms of the *rufa* group by their small size, opaque surface and peculiar coloring and pilosity. The following collector's note on the Isle Royale specimens adds some ethological characters which are not seen in the other small forms of the *rufa* group known to me: "The nests of this ant are one of the most conspicuous features of the drier tamarack swamps. They are rounded-conical in shape, 3-6 dcm. high or even larger and with a diameter at the base about equalling the height. They are composed within of *Sphagnum*, but as would be expected with such material, without any definite system of galleries. The outer surface is thickly covered with leaves of *Cassandra*, probably to prevent loss of moisture by evaporation from the interior. They are frequently placed near or under a bush of the *Cassandra*, but the same covering is used if no *Cassandra* is near." (H. A. Gleason).

7. *Formica rufa obscuriventris* Mayr. Workers from six colonies: 46 (I, 1), 47 (I, 1), 63 (I, 2), 76 (I, 2), 114 (I, 6), 14 (112) H. A. G. "This subspecies occurs on the rock beaches (I, 1, 46, 47) where it forages about on the surface and in crevices but is more abundant on the jack pine ridges (I, 5, 63) and on the rock clearings (I, 2, 76)."

I recently described this subspecies as *F. dryas*, but an examination during the past summer of some of Mayr's types in Professor Forel's collection, shows that in so doing I created a synonym. Mayr's original description based on specimens from Connnecticut is entirely inadequate, and the list of localities which he later cited for *obscuriventris* shows that he lumped together a number of different forms belonging to the *rufa* group The name *obscuriventris*, therefore, should be restricted to the form having the characters of my *F. dryas*. This ant is rare in the Eastern and Northern States and evidently belongs to the boreal fauna.

8. *Formica fusca* L. var. *subsericea* Say. Workers from 11 colonies: 23 (I, 5), 102 (V, 2), 131 (V, 2), C. C. A., and 80 (I, 5), 81 (I, 5), 100 (I, 5), 102 (I, 5), 223 (V, 3), 224 (V, 3), 226 (V, 3), 227 (V, 3)

H. A. G. Also specimens from a single colony on Mackinac Island (3, H. A. G.). "A common ant on the jack pine ridges (I, 5, 80, 81, 100, 102). It constructs its nests under rocks in moist soil (100) and was observed to capture beetle larvae (103). The specimens collected in the rock-clearings at Siskowit Bay (V, 3, 223, 224, 226, 227), constructed circular, flat-topped craters 6 dcm. in diameter, covered with debris of balsam and spruce needles and frequently with growing plants on them." This is the common form of the circumboreal *F. fusca* throughout Canada and the northern states. At higher altitudes on the Rocky Mountains it passes into the more silvery red-legged var. *argentata* Wheeler, a form which also occurs even near sea-level but very sporadically in the Atlantic States.

9. *Formica fusca* L. var. *neorufibarbis* Emery. A few workers from two colonies: 15 (I, 1) and 20 (I, 1) H. A. G. in vials with specimens of *Lasius neoniger* and *Camponotus whymperi*. Of the numerous varieties of *F. fusca* this is the most boreal, being known only from Alaska and British America as far east as Labrador and Nova Scotia, and from higher altitudes in the Rocky Mountains (9,000 to 12,500 feet). It forms rather small colonies under stones and logs in moist or shady places.

10. *Camponotus herculeanus* L. var. *whymperi* Forel. Workers from 10 colonies, with larvae and pupae: 15 (I, 1), 18 (I, 1), 22 (I, 1), 30 (I, 1), 62 (I, 2), 140 (I, 3) H. A. G. and 105 (V, 2), 126 (V, 11), 148 (III, '04), 149 (III, '04) C. C. A. "Although an abundant species on the rock and gravel beaches (15, 18, 22 H. A. G.) where it forages for dead insects, its actual home appears to be the ridges. On the dry ridges it occurs singly, usually in soil under stones (62, H. A. G.). It was also collected (140 H. A. G.) in the dense balsam fir woods, where it forages over the surface. This variation in habit leads to the conclusion that it belongs properly to the rock ridges." Like the preceding variety of *F. fusca*, *C. whymperi* is a truly boreal ant. It is our North American representative of the typical paleoboreal *C. herculeanus* and in the United States is known to occur only at considerable elevations in the Rocky Mountains (above 8,000 feet) and on the summits of the Green Mountains of Vermont. The types of *whymperi* were taken in the mountains of Alberta, B. C., by the noted mountain climber, to whom the variety was dedicated. I have seen specimens from Nova Scotia (Russell) and Labrador (Henshaw).

The foregoing series of Formicidae, though represented by only ten different forms, is of considerable interest on account of its pronounced boreal character. Only two of the forms (*Formica subsericea* and *Tapinoma sessile*) are abundant at ordinary elevations in the northern states. *Myrmica canadensis*, *Leptothorax canadensis*, *Formica aserva*, *F. obscuriventris* and *Lasius neoniger* occur sparingly in the same region, but always in situations which indicate that they are not in their optimum environment or station, or where they seem to represent the laggards of a wave of post-glacial migrants to more northern latitudes or higher altitudes. *F. adamsi*, *F. neorufibarbis* and *Camponotus whymperi* are exquisitely boreal ants of circumscribed alpine distribution in the United States, but probably of extensive range in British America.

THE COLD-BLOODED VERTEBRATES OF ISLE ROYALE.

DR. ALEXANDER G. RUTHVEN.

The collection which has served as the basis for this report was made by the University of Michigan Museum expedition to Isle Royale, in the summer of 1905. The report should be considered as supplementary to the papers upon the fish, amphibians and reptiles of the island, published in 1905. (Ruthven, 1905, pp. 107-112.) This, the second expedition to Isle Royale, has added a number of species to the fauna, and has established the fact that most of the previously known forms extend throughout the entire length of the island, which was, of course, to be expected.

The amount of data on this fauna accumulated by the two expeditions is considerable, when it is considered that up to 1904 practically nothing was known of the cold-blooded vertebrates of the Island. Our knowledge, however, is still very incomplete. In the case of the fishes this is due to the fact that no systematic attempt was made by the field parties to secure these forms, and the specimens obtained are, in most instances, those that came most easily to hand. The list is, therefore, undoubtedly very incomplete both as regards the number of species and their distribution. On the other hand, particular attention was paid to the amphibians and reptiles, and, although there is still much to be discovered concerning the local distribution of the species, the complete list includes nearly all of the species which would be expected to occur on the island.

Nature of the fauna.—The cold-blooded vertebrate fauna of Isle Royale, as at present known, consists of eighteen fish (exclusive of *Triglopsis thompsoni*, which was taken in deeper waters of Lake Superior), one toad, one tree toad, three frogs, the mud puppy, and two snakes.*

Affinities of the fauna.—Adams, on a previous page, has dwelt at length on the fact that Isle Royale has never been connected with the main land since glacial times, a fact that is of first importance in discussing the origin of the fauna. Most of the fish obtained on the island occur both in the inland waters and in the bays and coves about the shores. Since they are, moreover, forms of general distribution in the Great Lakes drainage system, occurring also in Lake Superior, their presence on Isle Royale is easily explained. To account for the presence of the inland, brook-dwelling forms, however, another explanation must be sought; for such species as the common stickleback, nine-spined stickleback, black-head minnow and *Leuciscus neogaeus* can hardly be conceived as able to cross the fifteen miles of open lake intervening between the island and the nearest mainland. At present we have no data that throw light on this problem.

The same difficulties arise in attempting to account for the origin of

* As elsewhere stated (Ruthven, 1905, pp. 109-112) *Hyla versicolor* and *Thamnophis saurilus* have been recorded from Isle Royale, but the records cannot be verified.

the amphibian and reptile faunas. As in the case of the fish, the species are all of general distribution in northeastern North America, but, with the exception of the mud puppy, none of the species recorded from the island are aquatic, and, as they also belong to groups which are very sensitive to cold, they could neither reach the island through the water in summer or over the ice in winter. The theory of involuntary transportation thus seems to be the only tenable one. At present the most plausible explanation for the presence of the reptiles and amphibians (with the exception of the mud puppy, which might swim across) found on the island is that they have been transported on driftwood.

Unlike several of the other groups of animals, and the flora, the amphibian-reptile fauna is not strongly boreal in its affinities. It is true that the forms which are found on the island also range to the northward, but the principal range of the species is to the southward, and only one species (*Rana septentrionalis*) does not extend rather far south in eastern North America. The southern affinity of this fauna is undoubtedly due to the fact that the amphibians and reptiles are both pre-eminently warm climate groups, and the representatives in this region are those few that are able to endure the colder climate.

ANNOTATED LIST.

Pisces.

1. *Catostomus commersonii* (Lacépède). Common Sucker. Taken in the southeast coves of Rock Harbor (III. 6). As this species was found in a similar habitat at the south end of the island in 1904, it is undoubtedly to be found in all of the suitable bays and coves along the shores, and probably also in the larger inland lakes.

2. *Pimephales promelas* Rafinesque. Black-head Minnow. Specimens of this fish were taken in Sumner Lake (III. 5). This is the only locality known for the island.

3. *Leuciscus neogaeus* (Cope). As in the case of the Black-head Minnow, this species was only taken in Sumner Lake (III. 5).

4. *Coregonus quadrilateralis* Richardson. Menominee Whitefish. This species, a common food fish in Lake Superior, was taken in Siskowit Lake (V).

5. *Argyrosomus artedi* (Le Sueur). Lake Herring. Taken by the 1905 expedition in Rock Harbor and Lake Desor (VII. '04). Like the Sucker this fish, which is a common Great Lakes species, probably occurs in most of the larger inland lakes.

6. *Argyrosomus nigripinnis* Gill. Blue-fin; Black-fin. This fish was only found in Rock Harbor.

7. *Cristivomer namaycush* (Walbaum). Mackinaw Trout; Lake Trout. Adult specimens were taken in Rock Harbor, and a single immature specimen (41 mm. in length) in Benson Brook (II. 1).

8. *Salvelinus fontinalis* (Mitchell). Brook Trout. The 1905 expedition secured specimens of the Brook Trout only in Benson Brook (II. 1). As it was found on the southern end of the island, in Washington Harbor and river, in 1904, it may be considered as occurring throughout the length of the island, in suitable habitats.

9. *Lucius lucius* (Linnaeus). Common Pike; Pickerel. Taken in Sargent Lake. This is apparently the only Isle Royale record.

10. *Eucalia inconstans* (Kirkland). Brook Stickleback. This species was found in the following localities: Tamarack swamps, Siskowit Lake (V. 5); Spruce swamp, Siskowit Lake (V. 11); Sumner Lake (III. 5). It is probably to be found in most of the ponds and small streams on the island.

11. *Pygosteus pungitus* (Linnaeus). Nine-spined Stickleback. The Nine-spined Stickleback is represented in the collection by specimens from the "Bulrush and Delta zone at the western end of Rock Harbor" (III. 3), and from Tobin Harbor (IV).

12. *Percopsis guttatus* Agassiz. Trout Perch. This fish was taken about a small island in Tobin Harbor (IV. 6).

13. *Perca flavescens* (Mitchell). Yellow Perch. Taken in Forbes Lake (II. 5). This species is probably to be found in most of the larger inland lakes as well as in the coves and harbors about the island. It was taken in Washington Harbor in 1904.

14. *Cottus ictalops* (Rafinesque). Miller's Thumb. This cottid was found along the shores of Rock Harbor (III. 6) and the island in this harbor (III. 2). As it was found in a similar habitat at the southern end of Isle Royale in 1904, it may be considered to occur throughout the entire length of the island in this habitat.

15. *Uranidea franklini* (Agassiz). There are specimens of this form in the collections, labeled Rock Harbor and Benson Brook (II. 1).

16. *Triglopsis thompsoni* Girard. Three specimens of this rare species were taken from the stomachs of Lake Trout (*Cristivomer namaycush*) taken by fishermen off the east coast of Isle Royale. Jordan and Evermann write of this form as follows: "Deep waters of the Great Lakes; not common; known from Lake Michigan and Lake Ontario; doubtless a relic of a former arctic marine fauna, and descended from a species of Onocottus." Bollman (1890, p. 225) records a specimen from Torch Lake, Michigan, which was also found in the stomach of a Lake Trout.

17. *Lota maculosa* (Le Sueur). Lake Lawyer; Burbot. Taken in Tobin Harbor (IV. 5) and Rock Harbor (III).

Amphibia.

1. *Necturus maculosus* (Rafinesque). Three immature amphibians that are undoubtedly this species were taken in Benson Brook. They are very young and lack the dorsal fin and stripes. Dr. L. Stejneger, who has kindly examined these specimens for us, states that the limbs and gills are proportionately shorter than the smallest in the U. S. National Museum. It should be noted here that Yarrow (1883, p. 144) has previously recorded this species from the island.

2. *Bufo americanus* (LeConte). Common Toad. The capture of a number of specimens of this species on the northern part (II) establishes its occurrence throughout the length of the island.

3. *Hyla pickeringi* (Storer). Pickering's Tree-frog. This amphibian was taken in the woods on the northern end of the island (IV. 8), and in the woods (V. 4) and Tamarack swamps (V. 5) in the vicinity of Siskowit Lake. It probably occurs also on the southern end of the island, although it was not taken by the 1904 expedition.

4. *Rana septentrionalis* Baird. Mink Frog; Northern Frog. A single specimen of *R. septentrionalis* was secured at Sumner Lake (III. 5). This establishes the presence of the species on Isle Royale, a point that

has hitherto been in question, owing to the unidentifiable condition of the specimens taken on the island by Dr. A. E. Foote (see Ruthven 1904, 110). Miss Dickerson (1906, 225) writes of the habits of this frog as follows: "The Northern Frog is described as decidedly a river frog; it is never captured in lakes and ponds." Our observations are exactly the reverse, all of the specimens taken on both expeditions having been found about the shores of the inland lakes.

5. *Rana clamitans* Daud. Green Frog. As represented by the collections of the 1905 expedition, this is the common frog of the island. Numerous specimens were taken on the shores of Rock Harbor (I. 1), at Sumner Lake (III. 5), and Siskowit Lake (V). Although it was not found on the southern end of the island in 1904, it doubtless occurs there.

6. *Rana sylvatica cantabrigensis* (Baird). Northern Wood Frog. This frog is now known from practically the entire length of the island. Specimens were taken by the 1905 expedition at Forbes Lake (II. 5), the small island in Tobin Harbor (IV. 6), and at Siskowit Lake (V. 5).

Serpentes.

1. *Storeria occipitomaculata* (Storer). Red-bellied Snake. This little snake is the characteristic reptile of Isle Royale. It was taken by the 1905 expedition at Rock Harbor (I. 7 and IV. 5) and Siskowit Lake (V. 5). No notes are available on the habits of the individual specimens obtained, but they are doubtless similar to those noted in 1904. As the variability of the scutellation of this snake has apparently never been determined, I add the scale formulas of the specimens examined.

Museum No.	Dorsals.	Supra-labials.	Infra-labials.	Tempo-rals.	Oculars.	Sub-caudals.	Ventrals.	Total length.	Tail length.
33475........	* 15	6	7	1–2, 1–1	2–2	....	115	....	....
33476........	15	6	6	1–2	2–2	46	122	250	60
33478........	15	6	7	1–2	2–2	48	124	263	63
33493........	15	6	7	1–1	2–2	40	121	230	59
33494........	15	6	7	1–2	2–2	41	121	200	40
33408........	15	6	6–7	1–3	2–2	43	127	298	61
33409........	15	6	7–6	1–3	2–2	43	126	310	59
33410........	15	6	7	1–2, 1–1	2–2	42	123	294	58
33411........	15	6	7–6	1–1, 1–2	2–2	42	125	291	56
33412........	15	6	7–8	1–1	2–2	....	122	....	....
33413........	15	6	7–?	1–2, 1–1	2–3, 2–2	39	120	238	49
33414........	15	6	7	1–1	3–2, 2–2	43	127	243	52
33415........	15	6	6	1–2, 1–1	2–2, 3–2	46	119	233	55
33416........	15	6	6	1–2	2–2	48	120	235	60
33417........	15	6	7	1–2	2–2	....	120	....	....

* In these specimens there is no decrease in the number of scale rows on the posterior part of the body. (Compare Ruthven, 1908.)

2. *Thamnophis sirtalis* (Linnaeus). Garter-snake. Garter-snakes were taken in the following localities: Light-house clearing (I, 7), Ran-

som clearing (II, 1), Shore of Siskowit Lake (V, 1), Sumner Lake (III. 5), Tamarack Swamp Rock Harbor (V, 5), and Siskowit Bay. The specimens of this snake obtained vary greatly in color. A number, like the few obtained in 1904, would be referred unhesitatingly to variety *parietalis,* were it not for the fact that there are other specimens in the collection which have a smaller amount of red on the sides, as well as some in which it is entirely wanting. When the series is examined as a whole it is quite evident that the specimens are intermediate between the typical form and variety *parietalis,* which is not surprising since the island lies in the latitude of the known "intermediate zone" to the southward (see Ruthven, 1908, p. 168).

This, however, in no way vitiates the statement made in 1904 that the presence of this snake on the island is an evidence of a western affinity in the fauna; for the frequent presence of a considerable amount of red pigment on the sides and the tendency toward the fusion of the upper row of spots, indicate that the Isle Royale specimens are more closely related to the western *parietalis* than to the garter-snake of eastern Canada and Northern Michigan, which belongs to the typical form, in that it never has the interspaces of the first row of spots entirely suffused with red, nor the upper row of spots usually fused.

A number of specimens from Rock Harbor, differ so much from the usual color of Isle Royale specimens as to merit special mention. The ground color in these individuals is black or blackish. The stripes are dark greenish, the dorsal being indistinct. The spots of the first row are distinct, the interspaces being of a light bluish color; the upper row of spots is usually fused except for short bars or spots of bluish. Belly dark blue with a black band on the outer margin of each scute. Supralabials dark blue, bases of the second to the fifth, white. Iris black. These specimens are identical with those from New Hampshire described by Allen (1899, 64) as *pallidula;* that they are only dark individuals of the form which inhabits the entire island is shown by the numerous "intermediate" specimens in this collection.

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ANNOTATED LIST OF THE BIRDS OF ISLE ROYALE, MICHIGAN.

BY MAX MINOR PEET.

1. Introduction.

Our observations on the birds of Isle Royale extended over the period between July 5 and September 22, 1905. Three parts of the island were studied, namely Rock Harbor, Siskowit Bay (especially near the outlet of Siskowit Lake), and Washington Harbor. The party remained at Rock Harbor from July 5 to August 1; at Siskowit Bay from August 1 to August 17; and at Washington Harbor from August 17 to September 22. At Rock Harbor the observations were made by O. M'Creary, N. A. Wood, and Dr. R. A. Brown. At Siskowit Bay the work for the first week was carried on by M'Creary and Wood, as Brown had left the island; on August 8 they were joined by the writer. On our arrival at Washington Harbor M'Creary left the island, and the work was continued by Wood and the writer until September 1, when the former was called home. However, he was forced by severe storms to remain on Washington Island at the mouth of the harbor until September 5, and while there made a number of observations which are included under their respective heads. The observations during the remaining period (September 1 to September 22) were made by the writer. Before joining the party at Siskowit Bay, he had spent three days, August 5 to 8, at Washington Harbor, the observations giving some idea of the bird life at that place before migration had set in.

Practically all the birds observed at Rock Harbor were nesting, those observed within a few days after our arrival at Siskowit Bay may also be considered as breeding, but after about the first of August it is not safe to say whether the bird nested there or was an early migrant. As an example of this we may cite the case of the Tennessee Warbler, which probably did not nest on the island, and yet was first observed there August 2. Unless the nest was found or young unable to fly, we did not consider them as breeding in that vicinity, if seen after August 1. In the case of the waders, the earliest migration date must be placed in the latter part of July.

Under the head of stations, the particular habitats in which the birds were actually found are given with their numbers, so that a fuller description of the conditions existing there can be easily obtained by referring to that number under the "Description of Stations." It must not be supposed that the birds were limited to the station in which they are recorded. In all probability the birds noted in one tamarack swamp would be found in nearly every similar habitat on the island. But owing

to the limited time spent here it was of course impossible to examine every locality, and so the records simply indicate the particular habitats in which the species under discussion were actually found. If observations were conducted for a sufficiently long period, the majority of the birds on the island would probably be recorded for nearly every habitat even if they did not breed in them; especially would this be true during migrations. It is not my intention, therefore, to give every habitat in which a particular species *might* be found, but rather to give the habitats which are preferred by that bird,—conditions which can be said to be characteristic of that species.

When a species was seen before the opening of migration, and yet no other signs of its breeding were found, it was considered simply as a resident, and the first and last dates when it was noted are given. The migration records of the resident birds are probably nearly all later than they should be, but the dates are given when they were first seen in actual migration. Many of the birds were still migrating at the time I left the island (September 21), and in such instances this is the last date given, and signifies that the migration of the bird was still under way. More extended observations on this interesting movement of the birds can be found in the paper "The Fall Migration of Birds," which is included in this volume. The paper on "The Ecological Distribution of Birds" should also be consulted for a discussion of that phase of the work.

From July 5 to September 22 we recorded 63 summer residents, 3 winter residents, 31 migrants, and 14 permanent residents, making a total of 111 species. In 1904 we observed eight birds which were not recorded the second year; these were: Sora, American Coot, Least Sandpiper, Short-eared Owl, Bronzed Grackle, American Goldfinch, Clay-colored Sparrow, and White-breasted Nuthatch. Besides these, the Clubhouse people described three other forms, the Snowy Owl, Snow Bunting, and Lapland Longspur, making a total of 122 species known to occur on the island. Many ducks come to the island, but the descriptions given by the fishermen were of no help in their determination. A complete list of the birds observed during the summer and fall of 1905, arranged as "Summer Residents," "Migrants," "Winter Residents," and "Permanent Residents," is included in this paper. Forty-two species were found breeding.

I have attempted to make this more than a simple annotated list—a list giving nothing but the occurrence, relative abundance, and dates of migration. Besides this usual data, I have given as complete a life history of each species as I could, using nothing but the original records secured by the expedition. All habitat records are also included so that the characteristic environment of the birds may be understood.

I wish to acknowledge my indebtedness to Mr. Chas. C. Adams for the opportunity of accompanying the expedition, and for his kindness and assistance in the preparation of this paper.

Specimens representing nearly every species found on the island were secured and are now in the collection of the University of Michigan Museum. For the determination of certain specimens we are indebted to Mr. H. C. Oberholser of the Smithsonian Institution.

2. *Classified List of Birds Observed in 1905.*

1. Summer Residents. * = Breeding.

*1. Pied-billed Grebe.
*2. Loon.
*3. American Herring Gull.
*4. American Merganser.
*5. Hooded Merganser.
*6. American Bittern.
7. Spotted Sandpiper.
8. Marsh Hawk.
9. Sharp-shinned Hawk.
10. Coopers Hawk.
*11. American Goshawk.
12. Red-tailed Hawk.
13. Red-shouldered Hawk.
14. Pigeon Hawk.
*15. American Sparrow Hawk.
16. American Osprey.
*17. Saw-whet Owl.
18. Black-billed Cuckoo.
*19. Belted Kingfisher.
20. Yellow-bellied Sapsucker.
*21. Flicker.
22. Whip-poor-will.
23. Night Hawk.
24. Chimney Swift.
25. Ruby-throated Hummingbird.
26. Olive-sided Flycatcher.
27. Yellow-bellied Flycatcher.
28. Alder Flycatcher.
29. American Crow.
30. Vesper Sparrow.
*31. Savannah Sparrow.
*32. Slate-colored Junco.
*33. White-throated Sparrow.
*34. Chipping Sparrow.
*35. Song Sparrow.
*36. Swamp Sparrow.
*37. Cliff Swallow.
*38. Barn Swallow.
39. Tree Swallow.
40. Bank Swallow.
*41. Cedar Waxwing.
*42. Red-eyed Vireo.
*43. Nashville Warbler.
44. Black-throated Blue Warbler.
*45. Myrtle Warbler.
*46. Magnolia Warbler.
47. Bay-breasted Warbler.
*48. Black-throated Green Warbler.
*49. Oven Bird.
50. Grinnell's Water-thrush.
*51. Mourning Warbler.
*52. Canadian Warbler.
53. American Redstart.
54. Winter Wren.
55. Brown Creeper.
*56. Red-breasted Nuthatch.
*57. Chickadee.
*58. Golden-crowned Kinglet.
*59. Wilson's Thrush.
*60. Olive-backed Thrush.
*61. Hermit Thrush.
*62. American Robin.
*63. Blue Bird.

2. Migrants.

1. Baldpate.
2. Green-winged Teal.
3. American Scaup Duck.
4. Canada Goose.
5. Wilson's Snipe.
6. Yellow Legs.
7. Greater Yellow Legs.
8. Solitary Sandpiper.
9. Killdeer.
10. Broad-winged Hawk.
11. Kingbird.
12. Phoebe.
13. Least Flycatcher.
14. Thick-billed Redwinged Blackbird.
15. Rusty Blackbird.
16. White-crowned Sparrow.
17. Lincoln Sparrow.
18. Migrant Shrike.
19. Philadelphia Vireo.
20. Blue-headed Vireo.
21. Black and White Warbler.
22. Tennessee Warbler.
23. Cape May Warbler.
24. Black-poll Warbler.
25. Palm Warbler.
26. Connecticut Warbler.
27. Wilson Warbler.
28. American Pipit.
29. Catbird.
30. Ruby-crowned Kinglet.
31. Gray-cheeked Thrush.

3. Winter Residents (migrants from the north).

1. Horned Lark.
2. Pine Grosbeak.
3. Northern Shrike.

4. Permanent Residents.

*1. Prairie Sharp-tailed Grouse.
*2. Bald Eagle.
*3. Great-horned Owl.
*4. American Hawk Owl.
5. Hairy Woodpecker.
6. Downy Woodpecker.
7. Arctic Three-toed Woodpecker
8. Northern Pileated Woodpecker.
9. Blue Jay.
*10. Canada Jay.
*11. Northern Raven.
12. Purple Finch.
13. White-winged Crossbill.
14. Pine Siskin.

3. *Annotated List.*

1. *Podilymbus podiceps* (6). Pied-billed Grebe.

Range: British Provinces southward to Brazil, Argentine Republic, and Chili, including West Indies and Bermuda, breeding nearly throughout its range.

Stations: Washington Harbor, X '04; Washington River, II '04.

Breeding: Brood of 5 young, Aug. 18.

The Pied-billed Grebe was not found either at Rock Harbor or Siskowit Bay, but was a common summer resident at Washington Harbor, frequenting the river and upper end of the Harbor.

Breeding Notes: A family consisting of two old birds and five young were seen almost daily at that place. They seldom came out into the harbor. Although very shy when approached from land I succeeded in getting quite close when in a rowboat. They were never seen to take wing, generally diving or swimming rapidly away upon the approach of danger. Sometimes when badly frightened, instead of diving, they would rise upon their small wings so that their feet just touched the surface and in this way half ran, half flew across the water. The young were still unable to fly by the middle of September, and I doubt if the parents had completed their moult sufficiently to use their wings much either. During the rainy days when the creek was swollen and very rapid the grebes generally stayed out in the harbor near the river's mouth. A shallow spot covered with water plants and grasses near the bend in the river was their usual feeding place.

2. *Gavia imber* (7). Loon.

Range: Northern part of northern hemisphere. In North America breeds from the northern tier of states northward; ranges in winter south to the Gulf of Mexico and Lower California.

Stations: Rock Harbor, III, 2; Sumner Lake, III, 5.
Siskowit Bay, V, 1; Siskowit Lake, V, 6.
Washington Harbor, X, '04.

Breeding: Two young, two or three days old, were taken on August 10.

Common summer resident throughout the island, as shown by such records as these: "Seven loons seen in the west end of Rock Harbor, July 13" and "eight adults seen at Siskowit Bay, August 1st." These

birds had not left the island September 21st, as the fishermen reported them at this time.

They appeared to be more common at the northern end of the island and at Siskowit than at Washington Harbor. It is doubtful whether any nested in the immediate vicinity of the latter place.

Breeding notes: From their actions a pair were supposed to be breeding on Sumner Lake (III, 5) during July, but no nest was found. As long as any one was in sight the pair remained together, calling and diving continuously, often coming up many rods from their diving point.

On August 10th, a pair of adult birds were found with their two young on Siskowit Lake. The birds were swimming together with their young close beside them. Although apparently not more than two or three days old, they were expert divers and could swim under water much faster than the boat could be rowed when pursuing them. When approached, the parents swam rapidly away, leaving the young to take care of themselves, which they seemed perfectly capable of doing, and would have, had it not been for the use of a shot gun. As the young were approached, they swam rapidly away at right angles to each other. Upon being closer pressed they dived, swimming under water for twenty or twenty-five feet. This was kept up until they were procured. The young at this early age were capable of performing that remarkable feat for which the adults are so noted—the act of swimming at different depths with the head still above the surface. This is not done by diving, but simply by sinking the body lower down as a fish might lower itself; no special motion is noticeable, the sinking being gradual, and seemingly without effort. Towards the last the young swam with only the head out of water. One which was only wounded we kept alive twenty-four hours, after which it was killed as there was no food which we could easily procure for it. When placed in a basin of water it swam briskly about, seldom using the whole leg, but simply the foot, bending at the upper end of the tarsus, which was moved back and forth with a fanning motion, the toes folding back on the forward stroke. It showed little fear, even when taken in the hand. Occasionally it uttered a call or cry, much resembling that of a young turkey. In the stomach of the other was found a dragon-fly nymph and four small fish about an inch and a half to two inches long, which shows that the fish diet is acquired early in this species. Low marshy land suitable for nesting sites occurred in some part of nearly every lake or bay on the island, and probably many breed here every year.

Miscellaneous notes: Many loons are caught each year on "set lines" and also in the gill nets on the shores of the island. One fine male was brought to the party by a fisherman, which was caught this way. The line had been sunk where the water was about 100 fathoms deep and about ten miles out in the lake from the Rock Harbor light-house. The line was down twenty fathoms, and this loon is supposed to have swam down this distance and taken the small herring used as a bait. The fisherman reported that this was a very common occurrence, the birds sometimes being found at the great depth of fifty and sixty fathoms; but this seems improbable. These birds roamed about much in the evening and during the night, their loud peculiar cry being heard at all

hours as they passed over the camp. Severe storms like those during the first few days of September drove the birds into the seclusion of Washington Harbor, where they were usually in pairs, and very shy.

3. *Larus argentatus smithsonianus* (51a). American Herring Gull.

Range: North America generally, breeding from Maine, northern New York, the Great Lakes and Minnesota northward; in winter, south to Cuba and Lower California.

Stations: Rock Harbor, I, 1; III, 2.
Siskowit Lake and vicinity, V, VIII, '04.
Long and Menagerie Islands, V, 10.
Washington Harbor, X '04, River, II '04.

Breeding: Young seen August 1 and 6.

Very abundant, their numbers at places being counted in thousands. This was the only gull seen on the trip. Gathering on the rocky islands in such numbers as to make them look like one solid mass of white, their cries were almost deafening. In the evenings they visited the various places where the fishermen had thrown away the fish cleanings. At these feasts the water would be fairly covered with the birds, which would remain feeding long after dark. No matter on what part of the island, within a mile or so of the water, these gulls were nearly always in sight.

Breeding notes: On August 1st, near Chippewa Harbor, a brood of these young were seen swimming with their parents, the former being unable to fly. On August 6th a visit was made to the breeding grounds of these species at Siskowit, V, 10. *Fig. 45.* Here a chain of small islands runs nearly parallel to the shore and about three miles distant from it. The largest of these is nearly two miles long, and from a few rods to a fourth of a mile wide. It is composed of red sandstone, which rises out of the lake at an angle of about 20°. The rocks are almost bare of vegetation, but above the wave swept zone there is a narrow belt of shrubs and small trees.

As the island was approached, the rocks could be seen covered with the adult birds, which, however, soon took wing and circled about our heads, making a great noise. As we landed, many of the young birds jumped into the water and swam hastily away to the gathering flock of adults which was forming just out of range. Others ran and hid in the small bushes, while some, particularly the youngest, merely squatted down between the rocks, *Fig. 58*, their mottled, downy plumage furnishing such excellent protective coloring that many were actually passed over in the first search. The great mass of young remained about a quarter of a mile out in the lake, while overhead the parents flew and screamed. The nests were built in crevices, *Fig. 59*, and nooks in the rocks from near the water's edge to the top of the ridge which in some places was from ten to twenty feet high. Most of them were placed on the southern exposure and were composed of grass, sticks and such rubbish as was easily accessible. No fresh eggs were found, and the young birds appeared to be a month or more old.

The young when frightened squatted flat on the bare rocks, or squeezed themselves up in small nooks and crannies, trusting to their protective coloration for safety.

It is a common practice among the fishermen at Washington Harbor

to take the newly hatched young from the nest and raise them at their homes. Some who have a few chickens take the eggs and place them under a setting hen. These young soon become as tame as chickens, and feed upon any form of table refuse. The writer procured five of these young from some fishermen. They ranged in size from one about two months old and nearly able to fly to a little downy fellow scarcely three weeks old. These had all been obtained on some rocks just outside of Washington Harbor. They came into the writer's possession on August 8, and in a few days were turned loose on the beach in front of our camp on Siskowit Bay.

They ate everything offered them, vegetable as well as animal matter. Fish seemed to be particularly relished. Whatever they ate was swallowed entire if it could possibly be gotten into the mouth. One such instance was especially ludicrous. A northern red squirrel with simply the skin and head removed was fed to the youngest. Because of the weight it was with considerable difficulty that the squirrel was started in the right direction. The body was too long, so that when swallowed, the tail still protruded from the gull's mouth. By stretching its neck as high as possible, most of the tail disappeared, only to appear again as soon as the gull dropped its head down on its shoulders, and closed its eyes in the satisfied manner evinced by all the young gulls after a good meal.

Often when food was given to them they picked it up and walked to the water, swashing it around several times before eating. The downy young never ventured into the water where they would have to swim, preferring to stand on the beach where the waves would just lap their feet. The older ones often swam out a considerable distance from land and made the acquaintance of a young wild gull able to fly. After a few days this latter bird became tame enough to come on the beach to be fed. One of the most characteristic habits of the young gulls was to walk to the water's edge where the waves would just wash their legs, and dive the head down into the water, raise it quickly and throw the water over their backs, at the same time giving the tail a few jerks sidewise. This performance was repeated many times each day, often not five minutes apart. The young which had acquired their full plumage, but were not able to fly, could usually be told from those which were able to do so, by their manner of holding the head. The former rarely held the head erect, either when on the water or land, usually holding it well forward and often on a level with the back, while those able to fly held the head erect and nearly straight above the breast. The change appeared to take place immediately after the first flight. For many days before this occurred the young gull would be seen jumping up and down on the beach, often to a height of two or three feet, flapping its wings rapidly at the same time. The first flight of our largest gull occurred one afternoon after one of these performances. Making a short run down the sloping beach it rose on its wings with a few rather uncertain strokes and sailed out over the harbor. The flight must have covered half a mile when it returned and alighted on the water near camp. Its alighting was anything but graceful, for not being used to this new method of locomotion, it raised its wings straight over its back and dropped heavily into the water, nearly submerging itself. When

it rose to the surface and had completely arranged its feathers, it held its head upright, like the adult gulls, as if proud of its performance.

General Notes: The Herring Gull's manner of feeding was interesting. When small bits of fish were thrown on the water, the birds would fly down and just pat the water with both feet, at the same time lowering the head and picking up the morsel with the bill, not even stopping in their flight. When the piece was too large to pick up, the bird alighted near it, and either picked it to pieces or swallowed it whole. They were often seen dropping into the water from a considerable height, apparently catching small fish. The Herring Gull is sometimes taken on set lines like the loon, only in this case the hook must be near the surface. While on "Long Island" (V, 10) the dried body of an adult bird was found with a large fish hook attached to a short line in its throat.

The majority of these birds go south with the freezing of the lake; a few, however, remain throughout the winter around the fishermen's huts. Wherever a cut is made in the ice at this time, many of these gulls may be found.

4. *Merganser americanus* (129). American Merganser.

Range: North America generally, breeding south in the United States, to Pennsylvania and to the mountains of Colorado and California.

Stations: Lake Superior (Rock Harbor), I, 1. III, 2. III, 3. II, 4.
Siskowit Bay, V, 1. Siskowit Lake, V, 6.
Washington Harbor, X, '04.

Breeding: July 13, young; also July 27.

The American Merganser is a rather common species on the island, breeding in suitable localities.

Breeding Notes: The fisherman reported several families of adults and young at McCargoe Cove on July 11, and on the 13th a female with several young was seen in the west end of Rock Harbor (III, 3). A much larger flock of young was seen with the female at this same place on July 27th.

At Siskowit Lake (V, 1), on August 1, a large flock of young not yet able to fly were found, and on August 8 another flock barely able to use their wings were met near the Siskowit Islands. As many as twenty-two young were counted with one female. No young were found this year on Washington River, but several were seen out in the Harbor, which might have been raised here.

5. *Lophodytes cucullatus* (131). Hooded Merganser.

Range: North America generally, south to Mexico and Cuba, breeding nearly throughout its range.

Stations: Lake Superior (Rock Harbor), I, 1.
Sumner Lake, III, 5.

Breeding: Young observed July 27.

This species was quite rare, being observed only three times on Sumner Lake (III, 5) July 26, 27, 29, and at the Caribou Islands on several occasions.

Breeding Notes: From the actions of the single females seen at Sumner Lake they were thought to have young in the vicinity, but none were found. On July 27 a female and six young were seen on the Caribou Islands. The young were very small, not more than two weeks old, and

by rowing fast they were overtaken, but escaped by diving. This same flock was seen in this vicinity several times afterwards.

6. *Mareca americana* (137). Baldpate.

Range: North America from the Arctic Ocean south in winter, to Guatemala and Cuba. Breeds chiefly north of United States.

Station: Washington Harbor, II, '04.

Migration: Sept. 5.

On September 5 a single individual was found on Washington River, II, '04. It was poorly colored; perhaps an immature specimen.

7. *Nettion carolinensis* (139). Green-winged Teal.

Range: North America. Breeding chiefly north of the United States and migrating south to Honduras and Cuba.

Station: Washington Harbor, II, '04.

Migration: September 4.

A flock of five appeared in the Harbor on the morning of September 4 but soon disappeared.

8. *Aythya marila* (148). American Scaup Duck.

Range: North America, breeding far north. South in the winter to Guatemala.

Stations: Siskowit Bay, V.
Washington Harbor, X, '04.

Migration: Aug. 4 to Sept. 1.

This duck was very rare here. One pair was found on Siskowit Bay near Wright's Island on August 4. Just before the hard storm which commenced September 1, a flock of these birds came into the harbor and were seen near Washington Island (X, '04).

9. *Branta canadensis* (172). Canada Goose.

Range: Temperate North America, breeding in the northern United States and British Provinces; south in winter to Mexico.

Stations: Washington Harbor, I, '04.

Migration: September 16.

On the afternoon of September 16, a solitary Canada Goose was observed flying over the island in a southerly direction. The residents on the island reported that in late October great flocks of geese pass over, sometimes stopping for a few hours, but never remaining for any length of time.

10. *Botaurus lentiginosus* (190). American Bittern.

Range: Temperate North America. South to Guatemala, Cuba, Jamaica and Bermuda.

Stations: Shore of Sumner Lake, III, 5.

Breeding: Dead young found on July 18.

Only one of this species was seen during both years, although there are many haunts which seem suitable for it. On July 18 and again on the 25th a single individual was flushed from the grassy bog along the edge of Sumner Lake.

Breeding Notes: An old nest was found July 18. It was on a grassy tuft in the bog, and contained an addled egg and two dead young. The nest consisted simply of a depression in the mat of green and dry grass.

11. *Gallinago delicata* (230). Wilson's Snipe.

Range: North and Middle America. Breeding from the northern United States northward; south in winter to the West Indies.

Stations: II, '04, Washington Harbor.
Migration: August 27 to September 21.

On August 27, one of these snipe was found in the marshy spot near the mouth of the river, and again on September 20 another was found in the same place. They were very wary and were only found by walking through the grass from which they were flushed. On several occasions, birds which might have belonged to this species were met after dark along the road to Wendigo, but owing to their very rapid flight, identification was uncertain.

12. *Totanus flavipes* (255). Yellow-legs.

Range: America in general, breeding in the cold temperate and subarctic districts, and migrating south in winter to southern South America.

Stations: Bulrush Zone and Delta, III, 3, Rock Harbor.
Siskowit Bay, Beach, V, 1. Washington Harbor, I, '04.
Migration: July 26 to September 15.

On July 26 a bird of this species was seen at close range at III, 3. Three others stopped on the bluff above the river September 15. They showed little fear, and appeared curious as I approached.

13. *Helodromas solitarius* (256). Solitary Sandpiper.

Range: North America. Breeding occasionally in the northern United States, more commonly northward and migrating southward as far as the Argentine Republic and Peru.

Stations: Siskowit Bay beaches, V, 1.
Washington Harbor, I '04.
Migration: August 6 to September 15.

This sandpiper was rather common throughout August at Siskowit Bay, being found mostly on the bare wave swept rocks. True to its name, it was rarely seen when not alone. The pure white underparts and olive fuscous head and back made it quite conspicuous as it teetered back and forth on the rocks. They were seldom seen at Washington Harbor, although on September 5 small flocks were seen all along the road to Wendigo. They were picking up food and paid little attention to the writer, simply running ahead a few feet when approached too closely.

14. *Actitis macularia* (263). Spotted Sandpiper.

Range: North and South America from Alaska, south to Southern Brazil. Breeds throughout temperate North America.

Stations: Rock Harbor, I, 1. Siskowit Lake, V, 6.
Siskowit Bay, V, 1. Menagerie Island, V, 10.
Washington Harbor, I, '04; X, '04.
Resident and Migrants: July 26 to September 16.

The Spotted Sandpiper appeared to be rare at the northern end of the island, but was rather common at the other two localities where observations were made. It was seen almost daily at Siskowit and was by far the most common wader seen on the trip. At Washington Harbor they often came around the dock and were also met with along the river and the road parallel to it. At this latter station the birds were probably migrants as they were not seen regularly, being present one day and absent the next with perhaps a day or two between their visits.

15. *Oxyechus vociferus* (273). Killdeer.

Range: Temperate North America, breeding north to Newfoundland and Manitoba, migrating to the West Indies and Central America and northern South America.

Stations: Rock Harbor region, II, 2. Washington Harbor, I '04.

Migration: July 13 to August 5.

Only one of these birds was seen at the northern end of the island; this was on July 13 when one was seen flying over the tamarack swamp (II, 2). No others were found until August 5 when a flock of three were seen feeding on the grassy slope of the first clearing (I, '04).

16. *Pediocaetes phasianellus campestris* (308b). Prairie Sharp-tailed Grouse.

Range: Plains and prairies of the United States east of the Rocky Mountains; north to Manitoba; east to Wisconsin and Illinois; south to New Mexico.

Stations: Partial clearings along Benson Brook, II, 1.
Old Burning, V, 9.
Old clearing and burning at end of Siskowit Bay, VII '04.

Breeding: July 25, female with young.

The Prairie Sharp-tailed Grouse was found at Rock Harbor and Siskowit Bay by our party and was reported at Washington Harbor by the residents who called it a pheasant. At the latter place during the fall of 1904, I observed what I still think was a young of this species, but as it was not procured, the record for this part of the island must depend almost entirely upon the reports of the keepers of the club-house and the fishermen. It was nowhere very abundant, but probably occurred much more plentifully than our observations would tend to indicate, as those parts which seem to be favorable for its home were the least worked by our party.

Breeding Notes: On July 25 a female accompanied by three young, about half grown, was found in a clearing on a small rock ridge near Benson Brook (II, 1). Mr. Kneutson of Park Place reported July 20, that the grouse nested regularly at his clearing (IV, 5) and that several broods of young had recently been seen there. He also said that during the previous fall he had found them very plentiful and tame at the clearing at McCargoe Cove (II, 4). The Malone boys at Menagerie Light-House reported these birds to be quite common breeders at the clearing when the old town stood near the head of Siskowit Bay.

Miscellaneous Notes: A Myrtle Warbler's nest was found July 7 near the head of Tonkin Bay (IV, 7), lined with feathers of the Sharp-tailed Grouse and Canada Jay. An adult bird was secured August 5 in a burnt clearing near the outlet of Siskowit Lake (V, 9). The crop contained fifteen fresh June-berries and three grasshoppers. On August 13, three adults were seen in the large clearing near the head of Siskowit Bay (VIII, '04). This was once a prosperous mining town but has been deserted since about 1879. A forest fire swept away nearly all the buildings, and since that time a second growth of birch, alder and low brush has covered a large part of it. But many acres are still bare or overgrown with long grass, principally timothy. It was in this clearing that the birds found the most favorable conditions, and were therefore more abundant here than at the other stations. An adult

female, about half moulted, was taken here on September 16. Its crop contained seeds and berries with portions of grasshoppers and other insects. The birds as a rule were very wary, and when approached either took wing or ran swiftly through the long grass. Their flight was swift and direct, accompanied by a whirring noise as they arose. During the fall they make local migrations and are reported to visit the clearings of Washington Harbor in quite considerable numbers. One was thought to have been seen here during the latter part of August by Michael Hollinger, a hired man at the Club-house.

17. *Circus hudsonius* (331). Marsh Hawk.

Range: North America in general. Breeds throughout its North American range.

Stations: Rock Harbor, Tamarack and Spruce Swamp, II, 2, 5. Washington Harbor, I '04.

Resident: July 13 to September 12.

On July 13 one of these birds was observed in a tamarack swamp at the end of the island. At Washington Harbor a female was seen flying over the clearing August 6, and again a female was found September 1 in a tamarack swamp on Washington Island.

Two old males were seen together several times on September 8 and again on the 12th in the trees bordering the first clearing, chasing small birds, probably Savanna Sparrows.

18. *Accipiter velox* (332). Sharp-shinned Hawk.

Range: North America in general. Breeds south to Panama throughout its North American range.

Stations: Spruce and Balsam Forest, I, 2-3; Forest, V, 4. Washington Harbor, I '04 (clearing); Forest, II '04; Clearing and Forest, X '04.

Resident: July 26.

Migration: Began about the first of August, continuing throughout our stay.

The Sharp-shinned Hawk was first seen July 26 at the western end of Rock Harbor. Only one specimen, a fine male, was found at Siskowit August 15, but at Washington Harbor it was rather common the first of August, and so increased in numbers that during September it became even more abundant than the Sparrow Hawk.

The Sharp-shinned Hawk, more than any of the other raptorial birds, timed their migration to that of the warblers and sparrows upon which they preyed. During migration they increased gradually from day to day, those which came in from the north remaining with those already here instead of passing on to the south, probably because of the very favorable feeding grounds offered by the clearings.

19. *Accipiter cooperi* (333). Cooper's Hawk.

Range: North America from southern British America south to southern Mexico. Breeds throughout its range.

Stations: Rock Harbor, II, 2; Washington Harbor, I '04.

Resident: July 18 to September 12.

This was one of the rarest hawks on the island although food was very abundant. It might be that the clearings were not extensive enough. One was seen at Rock Harbor (I, 2) July 18. Also at Washington on August 24, 29, 31 and September 12. On this last date several came

to the first clearing in search of small birds, many of which they caught in the burned area where Savanna and Lincoln Sparrows were quite abundant.

20. *Accipiter atricapillus* (334). American Goshawk.

Range: Northern and Eastern North America, south in winter to the middle states and southern Rocky Mountain region; casually west to Oregon. Breeding range restricted to the Canadian towns of the United States and northward.

Stations: Rock Harbor beach, I, 1, 4.

Breeding: Young seen and secured on July 26, 1905.

This rare hawk was seen but twice, once on a tree at the edge of the beach(I, 1) and again in the birch and spruce forest near the tamarack swamp (I, 4). This latter bird was secured and proved to be a young male. Professor W. B. Barrows, in a recent letter to the writer, gives this bird in Michigan as a "winter visitor," "irregular and no nesting data." The specimen secured was probably raised on the island, as July 26, the date when taken, is very early, for the migration of hawks especially for the immature birds, even in this northern region. Although a few Sparrow and Sharp-Shinned had already appeared at Washington Harbor at this date, they were nearly all old birds, and I think had simply gathered there from the surrounding territory. From all observations made, it seems evident that the young of the hawks do not migrate until some time later; therefore it seems probable that this immature male was bred on the island.

21. *Buteo borealis* (337). Red-tailed Hawk.

Range: Eastern North America, west to the Great Plains, north to about 60°, south to eastern Mexico. Breeds throughout its range, except possibly the extreme southern portion.

Stations: Rock Harbor, II, 1.

Resident: July 14.

The Red-tailed Hawk was only observed once during the two seasons spent on the island. This specimen was seen flying over a small clearing (II, 1) at Rock Harbor on July 14.

22. *Buteo lineatus* (339). Red-shouldered Hawk.

Range: Eastern North America to Manitoba and Nova Scotia; west to Texas and the Plains; south to the Gulf states and Mexico. Breeds throughout its range.

Stations: Rock Harbor, IV, 1.

Resident: July 20.

Like the Red-tailed, this hawk proved to be very rare, the only record being that of July 20 when one was seen pursuing a pair of Bald Eagles near the head of Tobin Harbor.

23. *Buteo platypterus* (343). Broad-winged Hawk.

Range: Eastern North America, from New Brunswick and the Saskatchewan region to Texas and Mexico, and thence southward to northern South America and the West Indies. Breeds throughout its United States range.

Stations: Washington Harbor, I, '04 (clearing), X, '04.

Migration: August 30, September 5 and 12.

This hawk was rare on the island and was only observed as a migrant. A single specimen was seen at the camp clearing (I, '04) on August

30 and another on September 5 at Washington Island (X, '04). Several were found September 12 accompanying the large bird wave. They were exceedingly shy and there might have been many present during the large bird waves, which, owing to this trait, were not identified.

24. *Haliaëtus leucocephalus* (352). Bald Eagle.

Range: North America at large, south to Mexico, northwest through the Aleutian Islands to Kamchatka. Breeds locally throughout its range.

Note. "The birds from Alaska and much of British America are considerably larger than those from farther south, and on this account have been separated as a distinct race (*Haliaeetus leucocephalus alascanus* Townsend)." Thus this new subspecies occurring in northern North America makes the old name of the Bald Eagle (*Haliaeetus leucocephalus*) apply simply to the southern form. Without doubt the ones seen here are referable to the southern form.

Stations: Rock Harbor, III, 2; Tamarack Swamp, II, 2; Tobin Harbor, IV, 7.
Siskowit Lake, V, 4.
Washington Harbor, X, '04; along Washington river, II, '04.

Breeding: July 20 two young still in the nest. July 24 an immature bird was seen at II, 2 and another at Siskowit Lake August 5. On August 8 a nest with one young was seen near Siskowit Lake.

This species was rather common when we consider how few large birds of prey are usually found in a limited district. They were seen at Rock Harbor, Siskowit Bay and Washington Harbor; only a lone male was seen at the latter place, however, and probably none bred in the vicinity.

Breeding Notes: On the morning of July 20 when near the head of Tobin Harbor (IV, 7) a large female flew out over the boat scolding and snapping her bill, as though a nest were near. A Pigeon Hawk soon attacked her, the eagle turning completely over in its efforts to strike its tormentor. The male shortly made his appearance, and a little further on the nest was discovered in a small ravine. It was situated in a tall poplar tree about sixty feet from the ground. The nest itself was very large, about five or six feet across the top and six or seven feet deep, and had probably been used for several years, the additions made each year soon making it quite bulky. It contained two young, one of which flew from the nest when approached. An immature bird was seen in a tamarack swamp (II, 2) near McCargoe Cove on July 24. On August 5 another young bird was seen at Siskowit Lake (V, 9) and on August 8 a nest was found about 125 yards north of the same lake in a small burning. It was situated in a dead Norway pine about sixty feet from the ground and was composed of sticks, making a mass at least four feet across. One young was in the nest. As the tree was approached the old birds circled overhead snapping their beaks, but did not dare to approach very closely. The immature specimen was procured and proved to be nearly feathered and about as large as the adults.

At Washington Harbor an old white-headed male was a frequent visitor, a dead limb of a giant white pine tree which stood near the shore being its favorite perch.

25. *Falco columbarius* (357). Pigeon Hawk.

Range: The whole of North America south to the West Indies and South America. Breeds chiefly north of the United States.

Stations: Trail to Siskowit Lake, V, 4.
Washington Harbor, clearing, I, '04.

Resident: July 20.

Migrant: August 5 to September 16.

The little Pigeon Hawk was rather rare here, but became more common during the fall migration. On July 20 one was seen near the head of Tobin Harbor pursuing a Bald Eagle. It was seen several times annoying these great birds at Rock Harbor and Siskowit Bay.

Breeding Notes: A young male was taken August 6 near our camp at Siskowit. Its cry closely resembled that of a Flicker.

I saw this species at Washington Harbor on August 5, 6, and 7 and again on the 23rd. After that it was occasionally seen, usually along the border of the road and clearings, until September 16, when the last specimen was taken. The only time when they occurred in appreciable numbers was during the large wave of September 12. At this time flocks of 6 or 8 were quite common and must have caused considerable damage to the warblers and sparrows on which they seemed to be feeding entirely.

Like the other small hawks, they preferred the border of clearings but were not as often seen far away from the forest as were the Sharp-shinned and Sparrow Hawks. Places where the forest had been cleared away and had not yet grown up to alders and birches, seemed to be the favorite haunt, but some were found in the heavy balsam forest where the other hawks just spoken of rarely ventured.

26. *Falco sparverius* (360). American Sparrow Hawk.

Range: North America east of the Rocky Mountains, and from Great Slave Lake south to Northern South America.

Stations: Spruce and Balsam Forest, I, 2-3. Partial clearing, I, 1.
Clearing along Benson Brook, II, 1.
Rock Ridge Clearing, II, 3. Forest, V, 4.
Washington Harbor clearing, I, '04, II, '04, X, '04.

Breeding: No nests were found but immature specimens were seen throughout July, August and September.

Migration: About August 1 until after September 21.

The Sparrow Hawk was not very common at Rock Harbor and was not often seen at Siskowit Bay. But at Washington Harbor they were very abundant and during the first part of the season considerably outnumbered all other species of raptores. They frequented the clearings, feasting on the swarms of grasshoppers which everywhere infested the open. The stumps at the edge of the first clearing were fairly covered with the legs and wings of these insects which had been pulled off before the bird would swallow them.

27. *Pandion haliaetus carolinensis* (364). American Osprey.

Range: North America from Hudson Bay and Alaska, south to the West Indies and northern South America. Breeds throughout its North American range.

Stations: Rock Harbor, I, 1. Siskowit Lake, V, 6.
Washington Harbor, X, '04.

Resident: Observed from July 5 to September 21.

These birds probably breed on the island, although no nests or young birds were found. They were often seen soaring over Rock Harbor in search of food, dropping into the water to catch a fish which would be taken to some near by land, the bird soon returning and repeating the act.

At Siskowit Bay two Ospreys were seen presumably catching herring, on August 2. These small fish often swam near the surface and were caught by the Herring Gulls as well as by the Ospreys, Loons and Kingfishers. During the time observations were made at Washington Harbor in 1905, only two individuals were seen, both at Washington Island. Several were observed at the upper end of the Harbor during the previous year.

28. *Cryptoglaux acadica* (372). Saw-whet Owl.

Range: North America at large, breeding from the Middle States northward, and in mountainous regions of the West southward into Mexico.

Stations: Washington Harbor, X, '04. In forest near Washington river, II, '04.

Breeding: Young in first plumage August 30.

This little owl may have been much more abundant on the island than our records would seem to indicate, its diminutive size and nocturnal habits easily permitting it to escape observation. The first record we have for the island was the capture of an adult bird on July 24 by two fishermen of Washington Harbor. The owl had evidently been lost in the fog as it settled on the fishing tug when about 4 miles out in the lake.

Breeding Notes: The other record was of a juvenile male taken in the balsam forest at this harbor. This specimen was sitting in an alder bush about two feet from the ground near the river. It possessed the beautiful brown plumage of the first moult and was undoubtedly bred near by. When dissected, a young deer mouse was found in the crop. For several nights past deer mice caught in exposed traps set near this place had been pulled out and it is possible that it was the work of this owl or its parents.

29. *Asio magellanicus occidentalis* (375). Great Horned Owl.

Range: Western United States, from Minnesota and Kansas to Nevada, southeastern Oregon, Utah, and Montana; south in winter to Iowa.

Stations: Washington Harbor, clearing, I, '04.

Resident: Throughout the year.

Breeding Notes: Three young were taken August 26, 1904 at the second clearing, Washington Harbor. These were the youngest specimens found and still possessed a considerable amount of the first downy plumage. This year (1905) the owls were observed practically throughout our stay at the Harbor (August 18 to September 16). These were mostly adults, although a few young were seen which were nearly full grown. The thick balsam forest was their usual hiding place by day, and at night they frequented the borders of the road and clearings where they could secure their prey. Two of the specimens procured this season were found sitting on the roofs of the deserted houses at Wendigo (in the third clearing). Here the numerous White-footed Mice and Northern Hares furnished them with an easily procured food, and small birds

were therefore probably seldom molested. Often the remains of hares were found along the road, showing where one of these birds had feasted. Of course many hares were killed by the lynx, but as a rule these animals carried their victims into the brush to devour them while the owls usually ate theirs in the open. Then too the lynx rarely ate the intestines while the owls nearly always did. These birds appeared at the clearings just at dusk, and sometimes in rainy weather they were seen along the road even at midday. Their actions when observed just after dusk reminded one of the love antics of the Flicker. Sitting on the end of the ridgepoll of a deserted house, they would bow and turn one way and then the other, bowing at every movement until their breast nearly touched the roof. They showed little fear at this time of night, and in fact appeared curious at our approach.

The Great Horned Owl was not seen at any other station by our party but was reported at Siskowit Bay by the Malone boys. They are reported to be much more common in winter than in summer and several pairs of wings were seen which had been taken at this season.

30. *Nyctea nyctea* (376). Snowy Owl.

Range: Northern portions of the northern hemisphere. In North America, breeding wholly north of the United States; in winter migrating south to the Middle States, straggling to South Carolina, Texas, California and Bermuda.

The Snowy Owl is a regular winter resident on the island and several were shot there during the winter of 1904. None were seen by our party, but the descriptions given by the club-house keepers leave no doubt of their identity.

31. *Surnia ulula caparoch* (377a). American Hawk Owl.

Range: Arctic America, breeding from Newfoundland northward and migrating in winter to the northern border of the United States. Occasional in England.

Stations: Old burning at Siskowit Bay, V, 9.

Breeding: Young August 4.

We have only one record of the Hawk Owl for the island, but this breeding record is one of the first authentic records for the United States. About 9 o'clock in the morning of August 4 an adult Hawk Owl was seen sitting on the top of a tall dead tree in a small burning (V, 9) near the outlet to Siskowit Lake. The sun was shining brightly, but appeared not to effect the Hawk Owl as it would the common species. A short distance away a young bird still in the downy plumage was found. When first seen it was sitting on a dead stub like a Sparrow Hawk, but soon went to another stub, uttering a shrill cry as it flew. The young bird was taken, and is now in the museum collection.

32. *Coccyzus erythrophthalmus* (388). Black-billed Cuckoo.

Range: Eastern North America, west to the Rocky Mountains, breeding north to Labrador, Manitoba, and eastern Assiniboia; south in winter to the West Indies and the valley of the Amazon. Accidental in the British Islands and Italy.

Stations: Partial clearing, II, 1.

It will be seen that Isle Royale lies very near the northern limit of the cuckoo's range. It was accordingly quite rare here, the only records being those of July 6, 7 and 9 at Benson Brook (II, 1).

33. *Ceryle alcyon* (390). Belted Kingfisher.

Range: North America from the Arctic Ocean south to Panama and the West Indies. Breeds from the southern border of the United States northward.

Stations: Harbor, III, 2. Bulrush zone and Delta, VII, 3.
Siskowit Bay, V, 1. Siskowit Lake, V, 6.
Washington Harbor, X, '04. Washington River, II, '04.

Breeding: An occupied nesting hole was found July 27 and another on the 28th. Also an old one August 6.

Migration: The last Kingfisher was seen September 16.

Throughout the island the Belted Kingfisher was a rather common summer resident, preferring the banks of streams and the shores of the lakes and harbors, although it was occasionally found in the cedar and tamarack swamps.

Breeding Notes: Near Light-house Peninsula (II, 1) a nest of this species was found July 27. It was dug in a sandy bank and probably contained young as the adult birds were frequently seen entering it. Another nest was found on the 28th near the trail to Summer Lake (III, 4). At Washington Harbor, on August 6, a nest was seen which the club-house keeper said contained 6 young the latter part of June or the first of July. The hole had been dug in a sandy bank, *Fig. 17*, about 5 feet high on the road to the second clearing and quite near the river.

The Kingfishers were very common along Washington River, and probably there were more seen here than at all the other localities on the island put together. They were usually found sitting upon a leafless birch limb overhanging the water, from which position they often sallied out to snatch up a fish or chase a companion. On the open lake the birds were commonly seen hovering about 30 or 40 feet above the water until a fish was located, when, closing the wings, they would make a sudden perpendicular drop, often completely disappearing from sight. On the Washington River they fed quite extensively upon brook trout.

34. *Dryobates villosus leucomelas* (393a). Northern Hairy Woodpecker.

Range: Northern North America south to about the northern border of the United States.

Stations: Tamarack and Arbor Vitae Swamps, I, 4. Balsam Forest I, 3.
Along Benson Brook, II, 1.
Forest, V, 4.
Washington Harbor, clearing and burned area, I, '04.

Resident: Observed from July 12 to September 12.

This Woodpecker is rather rare throughout the island. On July 12 one was procured in the balsam forest back of the Light-house (I, 3), and on the 13th one was taken in the birches along Benson Brook. They were found in nearly every kind of environment from the cedar and tamarack swamps, balsam and spruce forest, and open birch woods to the camp clearings and old burnings. They were rarely seen at Siskowit and seldom at Washington Harbor. Probably nearly all are resident throughout the year although none were seen after September 12.

35. *Dryobates pubescens medianus* (394c). Downy Woodpecker.

Range. Northern and eastern North America west to British Columbia and the eastern edge of the Plains; south to the Gulf of Mexico.

Stations: Siskowit Bay; Forest, V, 4.
Washington Harbor, clearing and burned area, I '04.
Resident: July 22 to September 17.

The first of this species was seen July 22 and was met with every now and then until September 17, although like the Hairy, it probably stays all winter. It was found in all locations, but preferred burnings and the more open birch woods.

36. *Picoides arcticus* (400). Arctic Three-toed Woodpecker.

Range: Northern North America from the Arctic regions south to the northern United States (New England, New York, Michigan, Minnesota and Idaho), and in the Sierra Nevadas to Lake Tahoe.

Station: Washington Harbor, clearing along road and burned area, I, '04.

The Arctic Three-toed Woodpecker was observed only at Washington Harbor, where it was very rare, only two specimens being found, September 7 and 12.

37. *Sphyrapicus varius* (402). Yellow-bellied Sapsucker.

Range: Eastern North America north to about Latitude 63° 30′ (north of Fort Simpson), breeding from Massachusetts northward; south in winter to the West Indies, Mexico and Costa Rica.

Stations: Forest, V, 4. Washington Harbor, balsams at edge of clearing, I, '04.

Migration: September 13.

A single specimen was found September 13 among the balsams at the edge of the road (I, '04). This was a young female and probably was raised on the island.

38. *Ceophloeus pileatus abieticola* (405a). Northern Pileated Woodpecker.

Range: Formerly the heavily wooded region of North America south of about Latitude 63°, except in the southern Rocky Mountains; now rare or extirpated in the more thickly settled parts of the eastern states.

Stations: Siskowit Bay, Forest, V, 4.
Washington Harbor, edge of clearing, I, '04, also dense forest.

Resident: Throughout the year. First seen Aug. 3; last on Sept. 18.

None of these birds were observed at Rock Harbor, but evidences of their work were numerous. Several were seen at Siskowit Bay and one near Siskowit Lake trail (V, 7). On August 8 two were heard near our camp, and by clapping the hands in imitation of their hammering they were called within fifty or sixty feet of us, when one was procured. Another was taken on August 8 near camp (V, 3).

They were very often heard at Washington Harbor and were seen quite often, usually in the morning, but in rainy weather their call could be heard all day. Several stubs containing nesting cavities were found and some of the birds procured were young of the year. The woodpeckers preferred the forest where large dead or dying trees were to be found, usually in the vicinity of clearings, the large birches usually being selected when feeding, possibly because they decayed much more rapidly and contained more larvae than the balsams and spruce. Unless called, the birds were very shy and difficult of approach, although when busily engaged in digging into a tree they would not leave

until nearly forced to for the sake of safety. Nearly all the smaller woodpeckers protect themselves by dodging around the trees, but the Pileated, possibly because of its large size, rarely attempts this, but flies away with a rapid, undulatory motion. When in full flight the white in the wings is very striking and seems to catch the attention when otherwise the bird might pass by unnoticed in the dark woods.

39. *Colaptes auratus luteus* (412). Northern Flicker.

Range: Northern and eastern North America west to the eastern slope of the Rocky Mountains and Alaska. Occasional on the Pacific slope from California northward.

Stations: Rock Harbor; Spruce and Balsam Forest, I, 2-3. Tamarack and Arbor Vitae swamps, 1, 4.
Partial Clearing, I, 1; along Benson Brook, II, 1, II, 4.
Siskowit Bay, Forest V, 4; Old Burning, V, 9.
Washington Harbor, border of forest and open clearing, I, '04.

Breeding: A young of the year was taken July 31.

While not a rare bird, it was not very abundant in the east end of the island, undoubtedly owing to the scarcity of suitable timber to nest in. Several individuals were seen, the first one on July 6 at the edge of the balsams along the clearing from the light-house to the fisherman's cottages at Rock Harbor (I, 3). They were occasionally noted in the cedar swamp at the end of Tonkin Bay (I, 4), and also in the birch forests near McCargoe Cove (II, 4). A young of the year was taken July 31 in the balsam-spruce forest (I, 3).

They were rather scarce at Siskowit Bay probably because the timber was mostly green balsam and spruce, as this bird prefers clearings and burned areas where it can get larvae from decaying trees, or where ant hills are abundant. The most favorable conditions existed at Washington Harbor where large clearings afforded the much coveted ants as well as dead trees. At this point, therefore, the birds were very common and continued to increase in number throughout our stay. Many of these birds were found dead during September but I was unable to determine the cause; it might possibly have been due to some parasite. The keeper at the club-house told me that the birds continued to increase through October and that towards the end of the season hundreds died, but he did not know the cause of their death. The Flicker probably gathers at the southwestern end from all over the island and possibly many come from the north shore, remaining here where such favorable conditions exist, until cold weather necessitates their journey onward.

40. *Antrostomus vociferus.* (417). Whip-poor-will.

Range: Eastern North America to the Plains, and from Latitude 50° south to Guatemala.

Stations: Border of clearing, II, 1.

One of these birds was heard calling in the edge of the clearings along Benson Brook.

41. *Chordeiles virginianus* (420). Night Hawk.

Range: Northern and eastern North America, west to the great plains and central British Columbia, and from Labrador south through tropical America to the Argentine Republic.

Stations: Rock Harbor, Light-house peninsula, I.
Siskowit Bay, V, 1.
Washington Harbor, clearing, I, '04.
Resident: July 6 to September 1.

First seen July 6 as it was passing over the Rock Harbor light-house. It appeared to be rare in this locality. On August 10, 11, 14, it was also observed at Siskowit, but was rare here also. At Washington Harbor it was very common, feeding either singly or in pairs or small flocks in all the clearings. Much of the food was taken on the wing, but grasshoppers were greatly relished, and these the birds pursued on the ground. There is little doubt but that these birds breed here in the clearings, but owing to the lateness of the season, no nests were found. I see no reason why these birds should not be found more plentiful at the other localities unless the clearings are hardly extensive enough to furnish the conditions best suited to them. Insect food seemed abundant everywhere on the island, so it seems that clearings were what was lacking. The birds commenced their migration towards night, and a little after sunset large flocks would be seen drifting slowly toward the south, catching their evening meal while on the way.

42. *Chaetura pelagica* (423). Chimney Swift.

Range.—Eastern North America north to Labrador and the fur countries, west to the Plains, and passing south of the United States, in winter, at least to Jalapa, Mexico and Cozumul Island.

Stations: Rock Harbor, I. Washington Harbor clearings, I, '04.
Resident: July 8 to August 19.

These birds were only occasionally seen at Rock Harbor, commencing with July 8. On August 1 it was found at Siskowit and the light-house keeper on Menagerie Island said that two pairs of these swifts nested in the chimney of the light-house, but he thought they had left about the first of August. At Washington Harbor, on August 19 a pair of these birds was observed circling over the clearings and nearby river, just at sunset. These were the only ones observed here either year.

Isle Royale being wooded for the most part with conifers and having very few buildings upon it, the cavities used by chimney swifts for nesting places are of course almost wanting. Conifers rarely offer any cavities except where the woodpeckers have dug out their burrows in the dead trunks so common in old burnings. Perhaps this is the reason why more were seen at Rock Harbor than at the other localities as at this station there were extensive burnings. Probably as Isle Royale becomes more settled and chimneys and other nesting places become more plentiful the Chimney Swift will become abundant, as it already is in some of the towns on the northern shore of Lake Superior.

43. *Trochilus colubris* (428). Ruby-throated Humingbird.

Range: Eastern North America to the Plains, north to the fur countries, breeding from Florida to Labrador, and south, in winter, to Cuba, Mexico and Veragua.

Stations: Menagerie Island, V, 10. Washington Harbor clearing, I, '04.
Resident: August 17 to 22.

A pair of these birds were seen on August 17 hovering over some

flowers on Menagerie Island. They were said to be seen here nearly every day and probably bred near.

A single male was seen on several occasions during August and September in the clearing at Washington Harbor. The cultivated nasturtiums and some wild flowers furnished it food. More of this species would probably live on the island if it were lumbered, thus making more extensive clearings where wild flowers could grow.

44. *Tyrannus tyrannus* (444). Kingbird.

Range: North America north to New Brunswick and Manitoba; rare west of the Rocky Mountains; winters in Central and South America.

Station: Washington Harbor, I, '04.

A single individual came to the clearing on the afternoon of September 4.

45. *Sayornis phoebe* (456). Phoebe.

Range: Eastern North America, west to eastern Colorado and western Texas, and from the British Provinces south to eastern Mexico and Cuba, wintering from the south Atlantic and Gulf States southward. Breeds from South Carolina northward.

Station: Washington Harbor, I, '04.

Migration: August to September 12.

The Phoebe was quite common throughout August and the first part of September leaving on the twentieth of the latter month. It was probably migrating, as I believe none nested at this end of the island. The edges of the clearings and along the road were the favorite places, and especially those parts where there were small burnings, the leafless bushes making ideal perches from which they would sally forth in true flycatcher fashion. Both young and adults were seen, sometimes in little groups of three or four.

46. *Nuttallornis borealis* (459). Olive-sided Flycatcher.

Range: North America, breeding from the northern and the higher mountainous parts of the United States northward to British Columbia and the Saskatchewan River. Accidental on the Lower Yukon and in Greenland. In winter, south to Central America, Columbia and Peru.

Stations: Rock Harbor, alder zone, I, 1. Tamarack and spruce swamps, II, 2, 5, IV, 7. Siskowit Bay, old burning, V, 9, V, 11. Washington Harbor, X, '04.

Resident: July 17 to September 3.

A rather common summer resident at Rock Harbor and Siskowit Bay and probably at Washington Harbor, although only one was seen there this year. In 1904, however, they were fairly common. On July 20, at the head of Tobin Harbor, one of these birds was seen, which probably had a nest close by, as it flitted from tree to tree, scolding and showing other signs of distress, which usually indicates a nest or young in the vicinity.

A pair was taken July 17 in a tamarack swamp (II, 2). They were quite common in open tamarack, spruce and cedar swamps, usually perching on top of the highest dead trees, and uttering at short intervals a loud, harsh cry. After a short flight for an insect, they generally returned to the same perch. At Siskowit one was taken August 11 in a tamarack-spruce swamp (V, 11) where they were fairly abundant. In nearly every swamp visited two or three pairs of these birds

were found, their harsh cry attracting instant attention. As a rule they were found in pairs with sometimes a third, perhaps a young one. The only record for Washington Harbor was one observed September 3 on Washington Island (X, '04).

47. *Empidonax flaviventris* (463). Yellow-bellied Flycatcher.

Range: Eastern North America west to the Plains, and from southern Labrador south through the eastern Mexico to Panama, breeding from the Northern states northward.

Stations: Rock Harbor, tamarack and arbor vitae swamps, I, 4, II, 2.
Tamarack and Spruce forest, II, 2, 5.
Washington Harbor, near river, II, 04.

Resident: July 14.

Migrant: September 13.

A pair of this species was seen in a tamarack swamp (II, 2) on July 14, and an adult female taken. Another pair was found in a cedar swamp (I, 4) July 26. These birds were sitting on top of high birch trees and one uttered a note which resembled that of the Wood Pewee. None were noted at Siskowit and only one at Washington Harbor. On the morning of September 13 an adult male was found dead near the river. It did not lie there the evening before, so probably died while passing over during the night. Many other species were found dead on this same morning, the day after the great wave, but no outward indications were evident which would point to the cause of death. It might be noted here that the temperature was a number of degrees below freezing. See discussion under head of "Perils of Migration."

48. *Empidonax traillii alnorum* (466a). Alder Flycatcher.

Range: Eastern North America from the Maritime Provinces and New England westward at least to northern Michigan, etc., breeding from the southern edge of the Canadian Fauna northward; in winter south to Central America.

Stations: Rock Harbor, alders, II, 1.
Washington Harbor, alders, II, '04.

The Alder Flycatcher appears to be very rare from our data, but owing to its small size and to the fact that much of its time is spent in thick alder bushes or the tops of the forest trees, it seems probable that it is more common than it appeared to be. Small Flycatchers were often seen in these situations, but could not be procured and without doubt many of these were alders. A single specimen was procured August 26 in a clump of tag alders near Washington River (II, '04).

49. *Empidonax minimus* (467). Least Flycatcher.

Range: Chiefly eastern North America, west to eastern Colorado and central Montana, south in winter to Central America. Breeds from the Northern States northward.

Stations: Washington Harbor, I, '04, II, '04.

Migration: August 20 to September 14.

The Least Flycatcher was noted only in migration, but some of the immature specimens were so young as to warrant the supposition that they breed on the island. The first were seen on August 20, and were abundant the rest of August and during the first large waves of Septem-

ber. They preferred the dead brush of the burning and the low open alders and birches along the road and clearings.

50. *Otocoris alpestris* (474). Horned Lark.

Range: Northeastern North America, Greenland, and northern parts of the Old World; in winter south in eastern United States to the Carolinas, Illinois, etc.

Stations: Washington Harbor, clearing, I, '04.

Migration: September 13 to 21.

Large flocks of Horned Larks appeared at the first clearing early in the morning of September 13. The birds continued to increase in number for several days, and were found almost entirely at the first clearing, which was considerably the largest. They were eminently birds of the open, not even being found in the most open forest. They showed little preference between the plowed ground and the grassy meadow, and fed on insects as well as seeds. Little fear was shown, and when shot at upon the ground they often rose up in a whirling flock and after circling about the clearing would return to the same spot. It was a common occurrence to see them rise suddenly, seemingly without cause, and fly rapidly away only to wheel about and return to their old feeding grounds after having gone a quarter of a mile or so. Occasionally American Pipits were seen in company with them, but usually because the feeding grounds of the two flocks overlapped. The first flocks numbered from 30 to 50, but soon they grew to two or three hundred, the birds being very gregarious at this time of the year and seldom found alone. In a good series taken at random from different flocks the females seemed to predominate. The birds were all highly colored, especially the males.

51. *Cyanocitta cristata* (477). Blue Jay.

Range: Eastern North America to the Plains, and from the Fur countries south to Florida and eastern Texas.

Stations: Rock Harbor, clearing along Benson Brook, II, 1. Siskowit Bay, Forest, V, 4; clearings, V, 1. II, 2. II, 3. III, 5. Washington Harbor, clearing, I, '04; Forest, II, '04.

Resident: July 13 to September 20.

Without doubt many of the Blue Jays winter on the island and none were seen which showed any indications of even a local migration, either from one part of the island to another or to the mainland. They were fairly common in the swamps and along the rock ridges at Rock Harbor. On July 13 several were seen in a tamarack swamp (II, 2) and a flock numbering six or seven were found along a rock ridge (II, 3), feeding in the mountain alders along the edge of the rock clearing. They were also noted at Sumner Lake on July 26. At Siskowit they were only occasionally met with, one specimen being taken on the trail to Siskowit Lake (V, 4) August 15. At Washington Harbor they were very common and were recorded nearly every day of our stay. The Blue Jays preferred the dry open birch forest and clearings or old burnings. Occasionally they were found in the swamps and also in the balsam forest along the river. It was, however, a bird of wide distribution and was liable to occur in any habitat.

52. *Perisoreus canadensis* (484). Canada Jay.

Range: Northern New York, northern New England, and northern

Michigan, northward to Arctic America.

Stations: Rock Harbor, tamarack and Arbor Vitae Swamps, I, 4; Partial Clearing, II, 1.
Clearing along Benson Brook, II, 1.; Tamarack and Spruce Swamp, II, 2, 5.
Siskowit Bay, Forest, V, 4.
Washington Harbor, clearing, I, '04; Forest II, '04, III, '04.

Breeding: July 7. Adult with young.

The Canada Jay is a common resident throughout the year, but appeared to be less abundant at Rock Harbor than at the other localities visited. It was found in nearly every form of habitat, but was most common about clearings and especially those where scraps could be picked up from camps. In the forest they showed a decided preference for coniferous trees and even when hunting for food about the camps they chose the balsams rather than birch or alder.

Breeding Notes: A female with one young was seen on July 7 near the Light-house at Rock Harbor, and on July 25 an old bird was found with two young. Occasionally both parents would be found together accompanied by one or two young.

53. *Corvus corax principalis* (486a). Northern Raven.

Range: Northern North America, south to British Columbia, northern Michigan, New Brunswick, Maine, New Jersey, North Carolina, etc.

Stations: Rock Harbor, Tamarack and Arbor Vitae Swamps, I, 4; Clearing I, 1.
Siskowit Bay, trail to Siskowit Lake, V, 4. VII, '04.
Washington Harbor, clearing, I, '04.

Breeding: See below.

The Northern Raven was nowhere common but seemed to occur in limited numbers all over the island. Three were seen in a cedar swamp (I, 4) on July 29, and a skeleton was found previous to this on the rocks near the light-house (I, 1). They were occasionally seen at Siskowit during August, usually flying overhead or at some natural clearing near the beach. At Washington Harbor they were only visitors, coming every now and then to the clearings where they fed on the grasshoppers which were so abundant. They were very wary.

Breeding Notes: Earle Kneutson of "Park Place" (IV, 5) said this species nested in the vicinity. While exploring the ruins of the deserted town (VII, '04) near the head of Siskowit Bay on September 10, a nest of the Northern Raven was found in the old stamp mill. It was placed in the small hollow formerly occupied by the metal plate upon which the head of the stamp fell. The side walls of the stamp mill are broken down in places so that the entrance to the interior was simple. The nest was about four feet square and the deepest part about a foot deep, and was composed of sticks varying in size from a quarter inch to three quarters in diameter and a foot to three feet long. Several tail feathers of the Raven were found in different layers of the nest showing that in all probability the mass was the accumulation of several years of nest-building and repairing. Smaller feathers were scattered about the nest and floor. The lining consisted of small sticks and roots loosely laid together, but forming quite a compact mass in connection with the other material.

The floor of the building was strewn with pellets consisting principally of fishbones, skeletons of small mice, and some insect remains. Under some of the rafters this had accumulated to such an extent that the deposit was four or five inches in depth. In places it was weathered so badly that it appeared simply as a mass of brownish earth.

54. *Corvus brachyrhynchos* (488). American Crow.

Range: North America from the Fur Countries to the southern border of the United States. Locally distributed to the west.

Stations: Rock Harbor, Beach, I, 1; Spruce and Balsam Forest, I, 2-3; clearing along Benson Brook, II, 1; IV, 9; III, 3. Washington Harbor, clearing, I, '04; Forest, VI, '04.

Resident: Throughout our stay.

The Crow was not common at any locality visited. It was occasionally met along the shore of Rock Harbor (I, 1) where it fed on the cleanings thrown out by the returning fishermen. Several were observed in the birch forest at the top of Greenstone Range (IV, 9) and also at the Bulrush Zone and Delta at the western end of Rock Harbor (III, 3), but the natural and artificial clearings proved to be the most favorable for these birds throughout the island. They were quite rare at Siskowit Bay, but proved to be quite common at times at Washington Harbor. Here they resorted to the clearings and roads where they fed greedily upon the swarms of grasshoppers. No nests were found, but young of the year were more abundant than adults at Washington Harbor. The residents reported that these birds leave the island the last of October.

55. *Agelaius phoeniceus fortis* (498). Thick-billed Redwing.

Range: Breeding range, Mackenzie River, Athabasca, and other interior districts of British America. During migrations, the Great Plains, from eastern base of Rocky Mountains to Manitoba (Red River settlement), Iowa (Burlington, October), Indian Territory (Beaver Creek, November) western Illinois (Henderson County, Morgan County, March) northern Kentucky (Mason Co., December) and southward through more southern Rocky Mountains to Arizona (Fort Verdi, December, February; Big Chino Valley, March), and western Texas (El Paso, February).

Stations: Washington Harbor, clearing, I, '04; forest along river, II, '04.

Migration, August 19 to Sept. 20.

By all odds the most abundant black bird on the island. On July 14 a Red-winged Blackbird was seen in a marsh at Rock Harbor, but was not procured, so identification, where so slight a difference exists as between the species and subspecies, was impossible. It is my opinion that this was the common Redwing (*Agelaius phoeniceus phoeniceus*) and not the northern form. On August 19 large flocks of the latter form came to the clearing at Washington Harbor (I, '04). On the day previous several specimens of *phoeniceus* were taken, but none were seen after this. The keeper at the club-house said none of these blackbirds had been seen before this date, and as we found none on any other part of the island (unless the one previously mentioned should have been *fortis*) it seems probable that this form does not breed on the island, and only appears here during the spring and fall migra-

tion. The people at the club-house reported that large numbers of Red-winged Blackbirds came to the island in the spring.

About fifty specimens in all were procured, which proved to be *fortis*. None were in the black plumage, and the scarlet shoulder patches were just showing through the pin feathers of those taken during August. A young male taken on September 16 was just about half moulted. The under-parts, except down the breast bone, have black feathers edged with brown; the central line and feathers covering the abdomen are still unmoulted and are fuscous with whitish borders. The head, throat and nape also unmoulted, as are the first four primaries. The next five are new, and the remainder old. Nearly all the secondaries are new, while the tertiaries are still unchanged. Only the central tail feathers have been moulted. The specimen thus presents a mottled appearance, glossy black alternating with brownish fuscous, the cinnamon tipped secondaries and back feathers adding to the appearance. The epaulets are a rich orange-brown, a few, particularly at the bend of the wing, being tipped with black. The plumage of the entire series varied greatly, according to the sex, stage of moult, and also individual variation. Some, males and females, have a decided pinkish tinge to the throat while others have a rich yellow sometimes grading into orange. As a rule the first four primaries seem to be the last feathers on the body to moult. A few adults taken on August 20 have moulted entirely, but the majority, especially the young, had just started to moult at this date. Stomach examinations showed the food to consist largely of grasshoppers, which were very plentiful at the clearing. These birds were larger than the average male which, as a rule, was considerably larger than the female.

The birds usually came in flocks numbering from a dozen to fifty or more. They came to the first clearing quite regularly throughout August, usually frequenting the brushy area, but extending out into the grassy meadow in pursuit of the grasshoppers. When shot into, the remnants of the flock would often wheel several times around the gunner's head, allowing themselves to be fired at repeatedly before leaving. These birds migrated almost entirely by day and toward dusk were often seen preparing to roost in a alder thicket at the first clearing. That the birds actually remained there for the night was several times demonstrated when they were driven from their retreat long after night fall.

56. *Euphagus carolinus* (509). Rusty Blackbird.

Range: Eastern North America, west to Alaska and the Plains. Breeds from northern New England, Northern New York, and Northern Michigan northward. Accidental in lower California.

Stations: Washington Harbor, clearing and burned area, I '04.

Migration: September 15 on.

Large flocks of Rusty Grackles appeared at the clearings on September 15 and were abundant the rest of the time I remained on the island. Males and females were in about equal proportion, and while the sexes were often found together in the same flock, there appeared to be flocks composed wholly of one sex. Like so many of the other migrants, they were seldom found out of a clearing, where they crammed themselves full of grasshoppers. As a rule the birds were more wary than the Northern Redwing, and were difficult of approach when in the open,

but when gathered into the brushy areas of the first clearing they probably felt more secure, as here I had no difficulty whatever in procuring specimens. The residents reported them abundant here during the spring migration.

57. *Quiscalus quiscula aeneus* (511b). Bronzed Grackle.

Range: From the Alleghanies and southern New England north to New Foundland and Great Slave Lake, west to the eastern base of the Rocky Mountains, and south to Louisiana and Texas. In migrations, the southeastern states, except Florida and the Atlantic coast district south of Virginia.

The Bronzed Grackle was not observed this year, and only one specimen was noted here in 1904. This one was secured August 19 at the third clearing (I, '04), and not at Station II, as published in the report of last year.

58. *Pinicola enucleator* (515). Pine Grosbeak.

Range: Northern parts of the northern hemisphere, breeding in North America from northern New England, Quebec, and Rocky Mountains in Colorado, and about Lat. 37° in the Sierra Nevada; northward nearly to the limit of trees; south in winter irregularly into northeastern United States.

Stations: Siskowit Bay, Trail through Balsam-Birch forest, V, 4.

August 14, M'Creary found two Pine Grosbeaks in the Balsams (V, 4). These were the only birds observed, but the species is probably much more common and we simply did not chance to observe them. This is the more likely as the Grosbeaks make little noise and keep in the tops of the conifers. As the greater part of the forests on the island are so dense that the tops are practically shut off from sight to one below, the birds could easily pass unnoticed.

59. *Lanius ludovicianus migrans* (622a). Northern Loggerhead Shrike.

Range: Greater part of the United States east of the Great Plains, but very local in more eastern districts; breeding north to New Brunswick (York County), Maine (Bangor), New Hampshire (Hanover), Vermont (Mount Mansfield, etc.), northern New York (Lewis and St. Lawrence counties), Quebec (Montreal), Ontario (Hamilton; Kingston; Beaumans), Michigan, Wisconsin and Minnesota, and southward to Midland Virginia and western North Carolina, Kentucky (probably also Tennessee), and eastern Kansas; in winter southward to Mississippi, Louisiana and Texas (El Paso, February; Fort Clark, January; West Caranchua Creek, January; Washburn, August).

Stations: Washington Harbor, clearing, I, '04.

A single individual was seen at the Camp clearing (I, '04) on August 23.

60. *Carpodacus purpureus* (517). Purple Finch.

Range: Eastern North America from the Atlantic coast to the Plains. Breeds from the Middle States northward.

Stations: Rock Harbor, Spruce and Balsam Forest, I, 2-3; Partial clearing, II, 1; Clearing near Benson Brook at II, 1. Siskowit Bay, Forest, V, 4; old burning, V, 9. Washington Harbor, border of clearing, I, '04; Forest, II, '04.

Resident: July 7-August 28.

The Purple Finch was rather uncommon all over the island. A fine male was taken on July 7 in the balsam and spruce forest (I, 3) at Rock Harbor and on July 24 a large flock was seen in the balsams just back of the light-house (I, 3). It was only observed a few times at Siskowit, but usually in the balsam forest. At Washington Harbor the only time it was observed was August 28. Although the bird was most abundant in the balsam-spruce forest, it also frequented old burnings, the borders of clearings and tamarack and cedar swamps.

61. *Loxia leucoptera* (522). White-winged Crossbill.

Range: Northern parts of North America, south into the United States in winter. Breeds from northern New England northward.

Stations: Rock Harbor, Spruce and Balsam Forest, I, 2-3; Tamarack and Spruce Forest, II, 2, 5.

Resident: July 13 to the last of July.

The White-winged Crossbill was quite common at the upper end of Isle Royale, but was not observed at Washington Harbor this season, although it was observed several times there in 1904. At Rock Harbor they were usually found in the sphagnum bogs (II, 2, 5) and late in July were seen several times near the light-house feeding on the pine cones.

62. *Spinus pinus* (533). Pine Siskin.

Range: North America generally, breeding in the British Provinces, Rocky Mountains, Sierra Nevada, and high mountains of Arizona, south to Lower California and the mountains of Mexico to Orizaba. Also breeds sparingly in northeastern United States.

Stations: Rock Harbor. Spruce and Balsam Forest, I, 2-3; Partial clearing, II, 1. Washington Harbor, Forest, II, '04.

Resident: July 9-September 18.

The Pine Siskin was only occasionally recorded from the vicinity of Rock Harbor, and not at all from the other localities. On July 9 while rowing around the islands in Rock Harbor (I, 1) several of these birds were seen and heard singing as they fed among the balsams on the edge of the islands. They were also observed on July 13 in a tamarack swamp (II, 2) and were seen several times in the forest near Rock Harbor Light-house.

63. *Poœcetes gramineus* (540). Vesper Sparrow.

Range: Eastern North America to the Plains, from Nova Scotia and Ontario southward; breeds from Virginia, Kentucky and Missouri northward.

Stations: Washington Harbor, II, '04.

Migration: August 22.

An immature Vesper Sparrow, the only one seen, was secured on August 22 in a strip of brush on the banks of Washington River.

64. *Passerculus sandwichensis savanna* (542a). Savanna Sparrow.

Range: Eastern North America, breeding from the northern United States to Labrador and Hudson Bay Territory.

Stations: Washington Harbor, clearings and burned areas, I, '04.

Breeding: An immature specimen taken August 6.

Migration: August 31 on.

While at Washington Harbor the first part of August several Savanna Sparrows were seen and a young one barely out of the nest was secured

on the 6th. They were frequenting the clearings, and the immature specimen procured was taken near one of the old houses at the first clearing. Upon our return to this locality on August 16 none were seen and they were absent until August 31, when a large wave of Savannas struck the island. For the remainder of my stay these sparrows were present, but the majority had passed on to the south, either slowly or with some of the other large waves. This species was very partial to the clearings and was especially abundant along the road where the very short grass did not interfere with their motions. The birds were quite tame and even entered the houses by the open doors and windows. During one day of the large wave a dozen or more were thus caught in the house I was living in, most of these entering my work room.

65. *Zonotrichia leucophrys* (554). White-crowned Sparrow.

Range: North America at large, breeding chiefly in the Rocky Mountains, the Sierra Nevada and northeast to Labrador. South in winter to the Valley of Mexico.

Stations: Washington Harbor, clearings and burned area, I, '04.

Migration: September 12 on.

This year the White-crowned Sparrow was much later in migration than in 1904, as none were seen until September 12 while the first date of the previous season was September 1. They were quite rare and were never seen in flocks of more than 5 or 6. The clearings, roadside, and old burnings were the favorite resort, but occasionally they were found busily scratching among the fallen leaves along the river.

66. *Zonotrichia albicollis* (558). White-throated Sparrow.

Range: Chiefly eastern North America, west to the Plains, north to Labrador and the Fur countries. Breeds from Montana, northern Wyoming, northern Michigan, northern New York, and northern New England northward, and winters from Massachusetts southward. Accidental in Utah, California, and Oregon.

Stations: Rock Harbor, natural rock clearings, 1, 2; Balsam-Spruce Forest, I, 3; Lake and Bay Beaches, I, 1; Jack Pine Ridge, I, 5; Sphagnum-spruce Bog, I, 6; Benson Brook and Ransom Clearing, II, 1; Tamarack Swamp, II, 2; Shore of Forbes Lake, II, 5; Rock Ridge Clearing, II, 3; Small Island, III, 1. Shore of Sumner Lake, III, 5.

Siskowit Bay, Balsam-Birch forest, V, 4; Beach, V, 1; Outlet of Siskowit Lake, V, 9; Rock Clearing, V, 3; Clearing, VIII, '04.

Washington Harbor, Clearing and Burned area, I, '04; Along river II, '04. Tamarack Swamp, V, '04.

Breeding: Young able to fly, July 7.

Migration: Last seen September 17.

The White-throated sparrow was very common throughout the Island, where it inhabited the open swamps and borders of rock clearings, although it was found in limited numbers in nearly every station examined. It can easily be considered one of the birds of general distribution on the island, chiefly frequenting certain habitats but not by any means restricted to these specific environments. These sparrows were seldom found feeding in the clearings any distance from shelter, but were usually seen along the borders of the forest or in the more open areas. Low, damp places where the decaying leaves formed a thick

mat on the cool earth were favorite feeding grounds. They were often associated together in small flocks of six or eight, the young as a rule outnumbering the adults. Their food apparently consisted largely of fallen seeds and small insects which they found under the ground rubbish by vigorous scratching, much like a barn-yard fowl. We found the White-throats rather timid, and when first startled they usually dived into the nearest thicket, soon to appear, however, if no further move was made, as if forgetful of our presence. Throughout the breeding season and even during September their plaintive song could be heard at almost any hour of the day and often in the night. It was usually rendered from some low branch or pile of brush; and in fact the birds were seldom found above the lower branches, the major part of their time being spent on the ground. In flight the White-throats closely resemble the Song Sparrow, flying low for short distances dropping suddenly out of sight.

Breeding Notes: On July 7 several young White-throated Sparrows, just able to fly, were seen with their parents at the edge of a clearing. A nest containing the nearly full fledged young was found in the grassy marsh around Summer Lake (III, 5) July 17. It was placed in a bunch of grass at the foot of an alder, and consisted entirely of dried grasses. The nest was placed about a foot above the water. Another nest was found July 18 in a tussock of grass at the foot of a willow bush. It was held about a foot above the water as was the previous one. The edge of the lake was only a couple of feet away, and a wave would have destroyed it had there been heavy winds. The forest was about two rods distant. Four bluish-white eggs heavily and irregularly spotted with brown were found in the nest, which was composed entirely of grasses. Many White-throats were heard in this habitat. Young able to fly and take care of themselves were seen throughout our stay at all parts of the island.

67. *Spizella socialis* (560). Chipping Sparrow.

Range: Eastern North America, west to the Rocky Mountains, north to Great Slave Lake, and south to eastern Mexico, breeding from the Gulf States northward.

Stations: Rock Harbor, natural rock clearings, I, 2; Open Balsam-Spruce forest, I, 3.
Siskowit Bay, Trail through Balsam-birch forest, V, 4; Outlet of Siskowit Lake, V, 9.
Washington Harbor, Clearing, I, '04. Border of forest along roads and river, II, '04.

Breeding: Chipping Sparrow and nest seen July 20.

Migration: These sparrows were seen throughout our sojourn on the island, but were migrating; those seen one day might be replaced by new flocks from the north the next.

The Chipping Sparrow was only abundant during the migrations; at other times it was of very local distribution, and occurred in limited numbers. The dense coniferous forest is unsuited to this sparrow, and this fact probably explains its comparative absence at Siskowit Bay camp where the clearings were very limited. They were usually found in pairs or families until the middle of August, when they collected into flocks numbering from a dozen or so to fifty or sixty.

Breeding Notes: The only nest which we found was placed in a birch in the spruce and birch forest near the light-house. The nest was in a little opening, and I doubt if the bird ever nests in the dense forest if other conditions are available.

68. *Junco hyemalis* (567). Slate Colored Junco.

Range: North America, chiefly east of the Rocky Mountains, breeding from the higher parts of the Alleghanies, the Catskills, and the mountainous parts of southern New England northward; south in winter to the Gulf States. Casual in California and Arizona.

Stations: Rock Harbor, Jack Pine Ridge, I, 5; Rock Ridge clearings, II, 3. IV, 1. III, 5.
Siskowit Bay, Forest, V, 4. V, I. V, 2. V, 3.
Washington Harbor, Clearing, I, '04; Forest, II, '04.

The Junco was a common species throughout the island, frequenting clearings, rock ridges, and old burnings. Several were seen on the Jack pine ridge along Conglomerate Bay (I, 5) on July 10, and the next day they were abundant on the rock ridge at Sargent Lake (II, 3). On July 19 a large flock was observed feeding in a small clump of dwarf cedars at Scovill Point (IV, 1). They were also noted at Sumner Lake (III, 5) on July 28. At Siskowit they were fairly abundant, preferring the natural and artificial clearings. They were quite plentiful at Washington Harbor, frequenting the same places as at the other localities. No nests were found but young in nearly all stages of plumage were seen throughout our stay.

69. *Melospiza cinerea melodia* (581). Song Sparrow.

Range: Eastern United States to the Plains, breeding from Virginia and southern portion of Lake States northward to the Fur Countries.

Stations: Rock Harbor, Lake and Bay Beaches, I, 1; Benson Brook and Ransom Clearings, II, 1; Small islands, III, 1.
Siskowit Bay, South Shore of Siskowit Lake, V, 6; Outlet of Siskowit Lake, V, 9; Long Island Gull Rookery, V, 10.
Washington Harbor, clearings, I, '04.

Resident: Rock Harbor, July 5. Siskowit Bay, Aug. 5. Washington Harbor, August 21.

Migration: None seen after August 24.

The Song Sparrow probably bred on the island, although no nests were seen. They were usually found feeding on the ground, scratching among the leaves and debris after the fashion of the White-throated Sparrows, although not to such a large extent as these latter birds.

70. *Melospiza lincolnii* (583). Lincoln's Sparrow.

Range: North America at large, breeding chiefly north of the United States (as far north as Fort Yukon) and in the higher parts of the Rocky Mountains and Sierra Nevada; south in winter to Panama.

Stations: Washington Harbor, clearings and burned areas, I, '04.

Migration: September 12 to 15.

Lincoln's Sparrow was very common September 12, 13, 14 and 15 at Washington Harbor. They were found along the roads, particularly the borders where the underbrush was thick, and in the clearings. They were very difficult of approach, skulking in the ground hemlock and rubbish along the roads or hiding in the piles of brush in the old burning at the first clearing.

71. *Melospiza georgiana* (584). Swamp Sparrow.

Range: Eastern North America to the Plains, accidently to Utah, north to the British Provinces, including Newfoundland and Labrador. Breeds from the Northern States northward, and winters from Massachusetts southward to the Gulf States.

Stations: Rock Harbor, Bulrush Zone and Delta, III, 3; III, 5.

Breeding: Adults accompanied by one young seen July 26.

Several of these birds were heard singing at the mouth of a little stream near the west end of Rock Harbor (III, 3). This was an ideal spot for this species as the stream was slow and deep, with grassy bogs and alder bushes along its banks. Others were noted on a grassy bog around Sumner Lake (III, 5). The single immature specimen observed was found at the west end of Rock Harbor, July 26.

72. *Petrochelidon lunifrons* (612). Cliff Swallow.

Range: North America north to the limit of trees, breeding south to the valleys of the Potomac and the Ohio, southern Texas, southern Arizona, and California; Central and South America in winter. Not recorded from Florida or the West Indies.

Stations: Rock Harbor, Scovill Point, IV, 1.

Breeding: Occupied nests July 19.

The Cliff Swallow was only found at one place on the island and only several pairs were seen here.

Breeding Notes: At Scovill Point (IV, 1) on July 19 a number of Cliff Swallows' nests were found placed on the bare face of the rocks. They were above the reach of the waves and were usually protected above by shelving of rock. The nest was composed of mud and lined with feathers but could not be examined closely. The probabilities are that they contained young, as the old birds continually flew to the nest and then away again, chattering all the time.

73. *Hirundo erythrogaster* (613). Barn Swallow.

Range: North America in general, breeding from the Fur Countries south into Mexico; visits the West Indies in migrations, and winters in Central America and South America.

Stations: Rock Harbor, Spruce and Balsam Forest, I, 2-3. Menagerie Island, V, 10.

Breeding: August 17, nest with young.

On July 9 a flock of these swallows stayed around the light-house and neighboring islands for some time and finally flew away toward the south.

Breeding Notes: At Menagerie Island we saw four nests in a small boat-house, on August 6. Several pairs of adults were flying about the buildings. On August 17 they were again seen and a fifth nest containing young was found, this time built against the bare cliff about twenty feet above the waves. A shelving of rock a few feet above protected it from the rain. This nest contained four young nearly able to fly. An old nest was placed a little ways from this one and in a like location.

74. *Iridoprocne bicolor* (614). Tree Swallow.

Range: North America at large, breeding from the Fur Countries south to New Jersey, the Ohio Valley, Kansas, and Colorado, etc., wintering from South Carolina and the Gulf States southward to the West Indies and Guatemala.

Stations: Rock Harbor, Spruce and Balsam Forest, I, 2-3.
Menagerie Island, V, 10.

Resident: July 17 to August 1.

A flock of twelve Tree Swallows was observed flying about Rock Harbor Light-house on July 20 and 21. It was also observed here on August 1.

75. *Clivicola riparia* (616). Bank Swallow.

Range: Northern hemisphere; in America south to the West Indies, Central America, and northern South America; breeding from the middle districts of the United States northward to about the limit of trees.

Stations: Rock Harbor, Ransom Clearing, II, 1.

A single specimen of the Bank Swallow was seen July 25 at Ransom Clearing (II, 1) near the mouth of Benson Brook. The scarcity of this species is probably due to the lack of suitable nesting places on the island. Scarcely a bank suitable for their burrows was found by our party.

76. *Totanus melanoleucus* (254). Greater Yellow-legs.

Range: America in general, breeding from Iowa and northern Illinois etc., northward, and migrating south to Chili and Argentine Republic.

Stations: Siskowit Bay, Beach, V.

A single specimen of the Greater Yellow-legs was seen on the beach at Siskowit Bay on August 1.

71. *Ampelis cedrorum* (619). Cedar Waxwing.

Range: North America at large, from the Fur Countries southward. In winter, from the northern border of the United States south to the West Indies and Costa Rica. Breeds from Virginia, southern Alleghanies, Kentucky, Kansas, Arizona, etc., northward.

Stations: Rock Harbor, Jack Pine Ridge, I, 5; Balsam-Spruce forest, I, 3; Benson Brook and Ransom Clearing, II, 1; Rock Ridge Clearing (burned over) II, 3; Small Island, III, 1.
Siskowit Bay, Border of Rock Clearing, V, 3; Trail through the balsam-birch forest, V, 4; Outlet of Siskowit Lake V, 9.
Washington Harbor, border of clearings, I, '04; Forest along river, II, '04; Washington Island, X, '04.

Breeding: See below.

The Cedar Waxwing was a rather uncertain bird in its distribution. Unless held to a limited region by its nest, it wandered about and was seldom seen in the same locality two days in succession. We usually found them in flocks of from 5 or 6 to 15 or 20. Small berries were greedily devoured by them, as well as insects, the latter often being taken on the wing. In this they were very graceful and rivalled the true flycatchers, their strong, graceful flight, together with their quickness making them quite expert on the wing. As a rule they were very quiet, especially in the vicinity of their nest. The Waxwing was usually found in open places, as borders of clearings, along water ways, and at sphagnum bogs.

Breeding Notes: A nest containing 5 eggs was found July 10 in a Jack pine tree on the Jack Pine Ridge, I, 5. It was held against the trunk by two small branches about ten feet from the ground. The eggs

were greenish brown speckled with black. The nest was composed of moss, gray lichen, and grasses and was lined with rootlets and the soft gray tree lichen. July 20 several nests were found on a small rocky island, III, 1. The nests were placed in small spruces and cedars and were from eight to fifteen feet above the ground. All were built of the gray hanging lichen which grew on the neighboring trees. Another nest of the Waxwing was found July 27 on a small island in Rock Harbor. It was about six feet from the ground in a White Cedar, and was composed of the usual gray lichen. It contained two nearly hatched young, and one egg. July 28 a nest was found on a horizontal limb of a birch, about ten feet from the ground. It contained three young. On two small islands in Rock Harbor 14 Waxwing nests were found. Here the nests ranged from three to twelve feet above the ground. Another nest was found July 28 which was placed on a limb overhanging the lake, and about ten feet above it. It contained several young. July 29 a nest was found along the path to the fisherman's cabin. It was on a birch about twenty feet from the ground, the highest nest seen. The nests of the Cedar Waxwings were placed in both conifers and deciduous trees, but all were composed of the gray tree lichen.

78. *Lanius borealis* (621). Northern Shrike.

Range: Northern North America, south in winter to the middle portions of the United States (Virginia, Kentucky, Kansas, Colorado, Arizona, northern California). Breeds north of the United States.

Stations: Washington Harbor, clearings at edge of forest, I, '04.
Washington Island, X, '04.

Migration: September 1 and 9.

At Washington Island (X, '04), September 1, a Northern Shrike was seen eating a small bird it had just caught. Another was seen in the first clearing September 9.

79. *Vireo olivaceus* (624). Red-eyed Vireo.

Range: Eastern North America west to Colorado, Utah, and British Columbia; north to the Arctic regions; south in winter from Florida to northern South America. Breeds nearly throughout its Northern American range.

Stations: Rock Harbor, Partial Clearing, II, 1; along Benson Brook, II, 1.

Rock Clearings, II, 3. Birch forest, III, 4. Forest, V, 4.

Siskowit Bay. Old Burning, V, 9. Washington Harbor. Along road in alders, I, 04.

Breeding: July 13, nearly full grown young.

Migration: September 12.

These birds seemed to prefer the more open growths of timber such as the birch forests which contained more or less of an undergrowth of aspens, such as was found along Benson Brook (II, 1), where many were seen. On July 20 we found this species in the valley at the west end of Tonkin Bay (IV, 7) in a second growth of birch and aspen. It was also found on the trail to Sumner Lake (III, 4) on July 27. At Siskowit it was not nearly so common and was observed only two or three times at Siskowit Lake.

It was observed only as a rare migrant at Washington Harbor. Only one, an adult male, being taken, September 12.

Breeding Notes: Probably the Red-eyed Vireo bred quite commonly in all suitable localities, but no nests were found. A pair was seen feeding nearly full grown young along Benson Brook (II, 1) on July 13.

80. *Vireo philadelphicus* (626). Philadelphia Vireo.

Range: Eastern North America north to Hudson Bay; south, in winter, to Costa Rica and Panama. Not recorded from Mexico or the West Indies. Breeds from Maine, New Hampshire, and Manitoba northward.

Stations: Washington Harbor Clearing, I, '04.

Migration: September 12.

The Philadelphia Vireo was by far the rarest of this family, only one pair being seen throughout our stay this year. These two were found on the morning of September 12 among the low alder bushes along the road between the first and second clearings (I, '04). The year before one was seen September 1 in about the same locality.

71. *Vireo solitarius* (629). Blue-headed Vireo.

Range: Eastern North America to the Plains, north to Hudson Bay and Fort Simpson. South, in winter, to Guatemala. Breeds from southern New England and the northern part of the Lake States northward.

Stations: Washington Harbor, alders at edge of clearing, I, '04.

Migration: August 30; September 12.

The Blue-headed Vireo was only observed on two occasions. On August 30 a pair was seen feeding in a low birch along the road from the first clearing (I, '04), and on September 12 another was noted in the same place also feeding among low birches and alders.

82. *Mniotilta varia* (636). Black and White Warbler.

Range: Eastern United States to the Plains, north to Fort Simpson, south in winter, through Central America and the West Indies to Venezuela and Columbia. Breeds from Virginia and southern Kansas northward, and winters from Florida and the Gulf States southward.

Stations: Siskowit Bay, Old Burning, V, 9. Washington Harbor, forest along river, II, '04.

Migration: August 3 and 31.

One of these warblers was seen on August 3 among the alders and dogwoods which formed a dense thicket at the outlet to Siskowit Lake. No others were seen until August 31, when a single individual was procured in an alder thicket along Washington River (II, '04).

83. *Helminthophila ruficapilla* (645). Nashville Warbler.

Range: Eastern North America to the Plains, north to the Fur Countries, breeding from the northern United States northward. Mexico and Guatemala in winter.

Stations: Rock Harbor, Lake and Bay Beaches, I, 1; Natural Rock Clearings, I, 2; Balsam-spruce forest, I, 3; Tamarack and Arbor Vitae swamps, I, 4; Benson Brook and Ransom Clearing, II, 1.
Siskowit Bay, Trail through Balsam-Birch forest, V, 4; outlet of Siskowit Lake, V, 9.
Washington Harbor, border of clearing, I, '04.

Breeding: July 11, 5 young.

Migration: Migrating at Washington Harbor from August 25 to Sept. 12.

The Nashville Warbler was usually seen near the tree tops, especially along the border of clearings. They showed quite a preference for the vicinity of high, open mixed forests.

Breeding Notes: We found a Nashville Warbler's nest in the side of a bluff about eight feet high. The nest was placed about two feet from the foot of the cliff, which was not quite perpendicular at this point. The nest was almost hidden by the moss, and was composed of moss from the trees, the lining being made of grasses. It contained five young, still in the down. There were several birch and spruce trees close to the nest, completely shading it from the sun. The top of the cliff was bare rock and entirely exposed. The parents fed in the tamarack swamp near by, but refused to come close to the nest while we were near.

84. *Helminthophila peregrina* (647). Tennessee Warbler.

Range: Eastern North America, breeding from northern New York and northern New England northward to Hudson Bay Territory; in winter south through Mexico to Costa Rica and Columbia.

Stations: Siskowit Bay, Forest, V, 4. Washington Harbor, clearings, I, '04, Forest, II, '04.

Migration: August 2 to September 18.

The Tennessee Warbler was perhaps the most abundant species of this family on the island, although it was only recorded as a migrant. The first seen was on August 2 in the coniferous and birch forest near our camp at Siskowit (V, 4). They were observed regularly after this date, but never in very large numbers. We noticed these birds soon after arriving at Washington Harbor (August 19). In a few days their numbers were greatly increased and they continued plentiful until the first of September, when their numbers gradually diminished until the 8th, after which time only scattered individuals were observed. On August 20 we saw flock after flock of these beautiful birds among the scrub growth of alder, birch, and balsam, along the road (I, '04), and also along Washington River (II, '04). They were evidently gathering for the long journey south and were busy feeding in the brush and low trees. On August 22 a large flock came into the door yard, feeding about the doorstep on crumbs which had been thrown there. They were also noticed diligently hunting over some wild mustard, scanning every leaf and blossom carefully.

85. *Dendroica tigrina* (650). Cape May Warbler.

Range: Eastern North America, north to Lake Winnepeg and Hudson Bay Territory, west to the Plains; breeds from northern New England northward; winters in the West Indies.

Stations: Siskowit Bay, Forest, V, 4.

Migration: August 15.

This species was seen August 15 in a tamarack swamp (V, 5) at Siskowit. About six or seven birds were seen in company with several other migrating warblers. This is the only record we have for the island.

86. *Dendroica caerulescens* (654). Black-throated Blue Warbler.

Range: Eastern North America to the Plains, breeding from northern New England and northern New York northward to Labrador, and in the Alleghanies south to northern Georgia; West Indies and Guatemala in winter. Accidental on the Farallon Islands, California.

Stations: Rock Harbor, Spruce and Balsam Forest, I, 2-3; Tamarack and Arbor Vitae Swamps, I, 4; Tamarack and Spruce Swamp, II, 2-5; Siskowit Bay, Forest, V, 4; Washington Island, Clearing, I, '04; Forest, II, '04.

Migrant: August 28; September 12.

The Black-throated Blue Warbler was not common on any part of Isle Royale. We found them in the spruce, tamarack and balsam forests and swamps, especially where there was considerable underbrush. No young were seen, although it undoubtedly bred on the island, as males and females were seen as early as July 8.

87. *Dendroica coronata* (655). Myrtle Warbler.

Range: Eastern North America, chiefly straggling more or less commonly westward to the Pacific; breeds from the northern United States northward, and winters from southern New England and the Ohio Valley southward to the West Indies, and through Mexico to Panama.

Stations: Beach at Rock Harbor, I, 1; Spruce and Balsam Forest, I, 2-3; Small Islands, III, 1. Forest, V, 4; Old Burning, V, 9. Washington Harbor, clearing, I, '04; forest, II, '04.

Breeding: Nest and young, July 7 and July 27.

Migration: Last seen on September 12.

The Myrtle Warbler was fairly common in the balsam and spruce forest, but was often found feeding along the rocky shores. Although a tree nester, and principally an arboreal feeder, it commonly descended to the ground in search of food; this was particularly noticeable on the bare rocks along the shore of Rock Harbor. They were not as common at Siskowit, and only scattered migratory flocks were observed at Washington Harbor.

Breeding Notes: A nest containing four well feathered young was found on July 7. It was situated in a Jack pine on the extreme edge of a cliff, and about forty feet above the water. The nest was placed at the end of a horizontal limb, about ten feet from the ground, six feet from the trunk of the tree, and directly over the water. It was composed of balsam twigs and needles and lined with feathers of the Sharp-tailed Grouse and Canada Jay, being a little larger than a Chipping Sparrow's. No overhanging branches afforded the nest any protection from the sun or storms. The surrounding trees were Jack pines and spruces. The bird flew directly to the nest as long as the observer was out of sight, but at other times it approached very cautiously, and when about fifty feet from the nest it would drop close to the ground, flying low until almost under the nest. It always left the nest by flying low along the top of the cliff. There was very little underbrush within fifty yards of the tree on which the nest was situated, and the surrounding Jack pines and spruces were scattered so that the sun had access to the ground. The small plant life was composed mostly of mosses and heath plants.

On July 27 another nest was found, this time on an island at the

north side of Rock Harbor. It was placed on a horizontal limb of a white spruce about six feet from the ground. Like the first one this overhung the water, but not so far above it. It was composed of small twigs and grasses, lined with feathers and contained three young about two days old. On July 28 a young Myrtle Warbler just out of the nest was found on a small island (III, 1). Four nests were found on two small islands near the end of Rock Harbor, one of which contained small and nearly full-fledged young July 21. The other two were empty, but gave evidence of having been recently used. They were all in coniferous trees and ranged from six to ten feet above the ground.

No nests were found at Siskowit, probably because the breeding season was nearly over, and due, in part also, to our short stay at this location. A juvenile male was taken here on August 3, and several were seen feeding in the tree tops near the outlet of Siskowit Lake (V, 9) August 5. At Washington Harbor they were observed on August 5, 6 and 7; after our return, from August 18 to September 12.

88. *Dendroica maculosa* (657). Magnolia Warbler.

Range: Eastern North America west to the base of the Rocky Mountains, and casually to British Columbia; breeding from northern New England, northern New York, and northern Michigan, to Hudson Bay Territory and southward in the Alleghanies to Pennsylvania. In winter, Bahamas, Cuba, and south through eastern Mexico to Panama.

Stations: Rock Harbor, Spruce and Balsam Forest, I, 2-3; Grove of Evergreens, I, 1, I, 4; Spruce and Cedars along Benson Brook, II, 1, II, 4. Siskowit Bay, Forest, V, 4. Washington Harbor, clearing, I, '04; Forest, II, '04.

Breeding: July 7, female and young.

Migration: August 28, September 12.

Magnolia Warblers were common in the balsam and spruce forests and also in the second growths of birch at all three localities, but could not be called migrants.

Breeding Notes: A female was seen feeding a young bird in the top of a birch tree on July 7. The same day a female was found in a spruce thicket feeding a young bird which had just enough feathers to enable it to fly six or eight feet. Another brood of four young were found just back of the light-house in a thicket of birch. These were scarcely able to fly, two being caught by hand. The following day (July 8) several families were found in the tamarack and arbor vitae swamps (I, 4). One brood was large enough to fly. They were also found quite regularly along Benson Brook (II, 1) and at McCargoe Cove (II, 4).

General Notes: During migration the birds preferred the banks of the river and the roadside, although scattered individuals were occasionally met with in the more open parts of the coniferous forest, especially where it was sufficiently open to allow the growth of birches.

89. *Dendroica castanea* (660). Bay-breasted Warbler.

Range: Eastern North America, north to Hudson Bay. Breeds from northern New England and northern Michigan northward, in winter south through eastern Mexico (rare) and Guatemala to Columbia.

Stations: Rock Harbor, Spruce and Balsam Forest, I, 2-3; Rock

Ridge Clearing, II, 3. Forest on Trail to Siskowit Lake, V, 4. Washington Harbor, clearing, I, '04; Forest, II, '04.

Resident: July 7.

Migrant: August 28; September 12.

Only a few of these birds were seen and it is probably an uncommon summer resident throughout the island. A fine adult male was seen feeding in the balsam-spruce forest (I, 3) July 7. On July 14 another male was observed in a thick second growth of birch, aspen and spruce, near the edge of the tamarack swamp (II, 2). From its actions we thought a nest was near, but it could not be found. A badly moulting male was taken August 8 near Siskowit Lake. At Washington Harbor it was observed only as a migrant, being observed from August 28 to September 12. At times, particularly during Warbler waves, they were abundant, but among all those observed, only a few adult males were seen, and the young greatly outnumbered the females.

90. *Dendroica striata* (661). Black-poll Warbler.

Range: Eastern North America west to the Rocky Mountains, north to Greenland, the Barren Grounds, and Alaska, breeding from northern New England and the Catskills northward. South in winter to northern South America, but not recorded from Mexico or Central America.

Stations: Washington Harbor, clearings, I, '04; Forest, II, '04.

Migration: August 25 to September 25.

At first the Black-polls were rather uncommon, but they rapidly increased in numbers until August 26, when the great wave of this species commenced.

91. *Dendroica virens* (667). Black-throated Green Warbler.

Range: Eastern North America to the Plains, north to Hudson Bay Territory, breeding from Connecticut and northern Illinois northward, and south along the Alleghanies to South Carolina. In winter, south to Cuba and Panama. Accidental in Greenland and Europe.

Stations: Rock Harbor, Natural Rock Clearing, I, 2; Balsam-spruce forest, I, 3; Tamarack and Arbor Vitae swamps, I, 4; Sphagnum-spruce bog, I, 6; Tamarack swamp, II, 2; Forbes Lake, II, 5; Birch Forest, III, 4.
Siskowit Lake, Balsam-Birch Forest, V, 4.
Washington Harbor, Border of Clearings, I, '04; Forest along river, II, '04.

Breeding: Young with adult seen July 9.

The Black-throated Green Warbler fed on the ground as well as in the tops of the trees, but the latter place was much preferred, and, except during the breeding season, when they hunt everywhere for food, they were usually found there.

Breeding Notes: A young Black-throated Green Warbler was seen in company with the male on July 9 in the tamarack swamp, I, 4. July 11 a nest containing young was found in a cedar tree about 20 feet from the ground. It was composed of moss and grass. The nesting site was in a rather open spot where the trees were mostly cedar and birch, and only a little underbrush and low vegetation was present. When we were near the nest the female Black-throat moved anxiously about from limb to limb, keeping up a constant chirping, but would not approach closely. Another nest containing young was found the same

afternoon. Both parents were very nervous in their movements, remaining within a few feet of the observer and scolding constantly. The male had food in its mouth when first seen. A male, female and young were found in a birch forest July 27.

92. *Dendroica palmarum* (672). Palm Warbler.

Range: Northern interior to Great Slave Lake; in winter South Atlantic and Gulf States, the West Indies and Mexico. Of rare but regular occurrence in the Atlantic States in migration.

Stations: Washington Harbor, clearings, I, '04; Forest, II, '04.

Migration: August 28 to September 21 on.

The Palm Warbler was second in numbers only to the Tennessee. From August 28 to the middle of September these birds were always found in considerable numbers along the road connecting the clearings. It was also found in the first clearing, usually near the border where the alders and other shrubs furnished a large share of its insect food as well as a protection from the numerous hawks. The birds were quite tame and often came into the house through the open doors and windows. The birds have a characteristic habit of jerking the tail up and down, which serves as an aid to identification at quite a distance. As a rule they were usually found in flocks, usually numbering about thirty or forty.

93. *Seiurus aurocapillus* (674). Oven-bird.

Range: Eastern North America, north to Hudson Bay Territory and Alaska, breeding from Kansas, the Ohio Valley, and Virginia northward. In winter Florida, the West Indies, southern Mexico, and Central America to Panama.

Stations: Rock Harbor, Sphagnum-spruce bog, I, 6; Benson Brook, II, 1; Birch forest, III, 4; Tamarack swamp, I, 4.
Siskowit Bay, Balsam-Birch forest, V, 4; Tamarack swamp, V, 5.
Washington Harbor, borders of clearings, I, '04; found along river, II, '04.

Resident: Rock Harbor, July 8. Siskowit Bay, Aug. 12.

Breeding: Young seen August 12.

The Oven-bird was not common on the island and occurred only in limited numbers in its favorite habitats, such as the cool, damp forest along the streams and in the tamarack swamp. No nests were found, but young able to care for themselves were taken in the tamarack swamp (V, 5) August 12. It was uncommon even in migration and was last seen September 12.

94. *Sciurus noveboracensis notabilis* (675a). Grinnell's Water Thrush.

Range: Western United States, from Indiana and Illinois westward to California, and north into British America. Casual in migrations eastward to the Atlantic coast. Winters from the southern border of the United States southward to Lower California, Mexico and northern South America.

Stations: Rock Harbor, Along Benson Brook, II, 1; Forest, V, 4; Siskowit Lake, V, 6; Old Burning, V, 9.
Washington Harbor, Clearing, I, '04; forest along river, II, '04.

Migration: August 5 to September 12.

On August 5 several Grinnell's Water Thrushes were seen at the edge of Siskowit Lake (V, 9). They frequented the borders of the lake, secreting themselves in the dense masses of fallen tree tops and rubbish. They were afterwards seen running along on the bare rocks and sand, at a distance being similar in their actions to the Spotted Sandpiper, as both birds run in about the same manner with the accompanying tipping up and down motions. These Water Thrushes could be as truly called "tip ups" as the Sandpiper and were often found standing on a rock or log tipping up and down and wig-wagging the tail. It was occasionally found on the Lake Superior shore near camp, but was nowhere as common as on the inland lakes or streams. At Washington Harbor they were found along the road, in the dense balsam forest and along the river. During rainy days, especially, the Water Thrushes were quite common along the road, more particularly in the damp places where the alders thrived. Usually the birds were in pairs and were very shy. About the only way specimens could be procured was to call the birds near by sucking or kissing the hand to make a noise resembling that of a young bird in distress. This seldom failed to bring a pair or two of excited birds within a few feet. As soon as the deception was discovered they were quick to seek the protection of the long grass on the banks of the stream or of a nearby rubbish heap.

This bird probably breeds on the island, although nothing definite was determined. While at Washington Harbor earlier in the season I shot a young Water Thrush unable to fly, but could not find it among the dense underbrush and ground hemlock which covered the ground. An adult with three or four young was seen with it, but it was too dark under the thick balsams to see the color of the breast, or determine in and other way whether it was Grinnell's or the Small-billed Water Thrush.

95. *Geothlypis agilis* (678). Connecticut Warbler.

Range: Eastern North America, breeding north of the United States (Manitoba, Ontario). Northern South America in winter.

Stations: Washington Harbor, clearing at edge of forest, I, '04.

Migration: September 12.

Several Connecticut Warblers were seen during the large wave of September 12. They were found singly in the damp alder thickets along the road. In actions they reminded one of the Water Thrush, running along the fallen logs and keeping out of sight as much as possible.

96. *Geothlypis philadelphia* (679). Mourning Warbler.

Range: Eastern North America to the Plains, breeding from the mountainous portions of Pennsylvania, New England, New York, and northern Michigan northward. Central America and northern South America in winter. Accidental in Greenland.

Stations: Rock Harbor, burned area of rock ridge clearings, II, 3; Shore of Benson Lake, II, 1.

Breeding: July 11, young seen.

An adult female Mourning Warbler was seen near Benson Lake July 11, and near the outlet into Benson Brook an immature bird was seen on the same day.

97. *Wilsonia pusilla* (685). Wilson Warbler.

Range: Eastern North America, west to and including the Rocky Mountains, north to Labrador, Hudson Bay Territory, and Alaska. Breeds chiefly north of the United States, migrating south to eastern Mexico and Central America.

Stations: Washington Harbor, forest near river, II, '04.

Migration: August 31, September 5.

Wilson's Warbler was one of the rarest of this family, only two birds being observed on the island. On August 31 a female was seen catching insects over the river and also picking something off the leaves on an overhanging alder bush. The other was a male and was found in nearly the same place.

98. *Sylvania canadensis* (686). Canadian Warbler.

Range: Eastern North America, west to the Plains, and north to New Foundland, southern Labrador and Lake Winnipeg; south in winter to Central America and northern South America. Breeds from the higher parts of the Alleghanies and the more elevated parts of southern New York and southern New England, northward.

Stations: Rock Harbor, Alder zone, I, 1.

Breeding: July 8.

Just above the beach at the head of the bay at Rock Harbor is a partial clearing fringed with alders, and here among the bushes, fallen trees, alders, birches, and spruce we found a number of warblers, among them being the Redstart, Canadian and Nashville Warblers. The Canadian gave unmistakable evidence that it had a nest near by containing young. It scolded and fussed, approaching the intruder and fluttering rapidly away as if frightened at every movement in its direction, all the while holding food in its mouth.

99. *Setophaga ruticilla* (687). American Redstart.

Range: North America, north to Fort Simpson; west regularly to the Great Basin, casually to California and Lower California; breeding from the middle portion of the United States northward. In winter, the West Indies, southern Mexico, Central America, and northern South America.

Stations: Rock Harbor, Alder zone, I, 1; Benson Brook, II, 1.
Siskowit Bay, Outlet of Siskowit Lake, V, 9.
Washington Harbor, borders of clearings, I, '04; forest along river, II, '04.

Breeding: August 3 a male and young were seen.

Migration: Last seen September 8.

The Redstart was a much rarer breeder on the island than one would suppose. It was not near the limit of its range in any direction, and the conditions were the same as found elsewhere where it is quite plentiful. During migration it was quite common, but it never occurred in flocks like the Tennessee or Blackpolls, but was usually found associated with flocks of other species. The only young bird found was on August 3, when a male Redstart was seen feeding a young one near the outlet of Benson Brook, II, 1.

100. *Anthus pensylvanicus* (697). American Pipit.

Range: North America at large, breeding in the higher parts of the

Rocky Mountains and sub Arctic districts, and wintering in the Gulf States, Mexico and Central America. Accidental in Europe.

Station: Washington Harbor, clearings, I, '04.

Migration: September 18 on.

Large flocks of the American Pipit appeared in the first clearing at Washington Harbor on September 19. More also came on the next two succeeding days and probably continued to come, but on the 21st I left the island for the south. They came in flocks numbering from 30 to 150 and 200. The grassy clearing was preferred to the plowed area, possibly because it offered many more insects at this time of year. Small seeds, probably of the wild grasses, were found in some of the stomachs. The birds as a rule were not shy, even flying around one's head and alighting within a few feet after being shot at. When in the long grass it was sometimes difficult at a distance to distinguish them from Palm Warblers, as the latter has much the same colored back, and often resorted to the same places to feed. On the open ground of course there was no such difficulty. Even when in the field the exceedingly long hind toe nail is very conspicuous. The Pipits were very nervous in their actions, only feeding in the same place a few moments at a time and then rising up in a scattered flock they drew close together into one compact mass of whirling birds and flying a short distance would wheel around and return to the same location.

101. *Galeoscoptes carolinensis* (704). Catbird.

Range: Eastern United States and British Provinces west to and including the Rocky Mountains; occasional on the Pacific coast, from British Columbia south to Central California. Breeds from the Gulf States northward to the Saskatchewan. Winters in the southern states, Cuba, and Middle America to Panama, Bermuda, resident. Accidental in Europe.

Stations: Washington Harbor, forest near river, II, 1.

Migration: September 12.

Only one individual of this species was seen during the two years of work here. Late in the afternoon of September 12 I took a single specimen as it was passing through a dense thicket of mixed alder, birch and balsam on the steep banks near the river.

102. *Olbiorchilus hiemalis* (722). Winter Wren.

Range: Eastern North America generally, breeding from the northern parts of the United States northward, and in the Alleghanies south to North Carolina, and wintering from about its southern breeding limit southward.

Stations: Rock Harbor, Tamarack and Arbor Vitae swamps, I, 4; III, 5; burned clearing near I, 1; thick undergrowth along Benson Brook, II, 1; Tamarack and spruce forest, II, 2, 5.
Siskowit Bay, forest, V, 4.
Washington Harbor, forest near river, II, '04.

Resident: July 13 to September 18.

These little birds were very partial to the tamarack and cedar swamps where they would be heard singing from the very tops of the tallest trees. They were often found in a small tamarack swamp (II, 2) at the west end of Rock Harbor and in the tamarack swamps around Sum-

ner Lake (III, 5). A pair was suspected to nest in a small tamarack swamp, (I, 4) but the nest could not be found in the thick tangle of logs and brush. It was often heard singing along the shores of the lakes and bays, preferring places where there was a rank growth of ground hemlock. We found it fairly common all through the regions studied, but in each place the birds were found in the same environment. Those taken at Washington Harbor were found in the wet, dark forest along the river.

103. *Certhia familiaris fusca* (726). Brown Creeper.

Range: Eastern North America, breeding from the northern and more elevated parts of the United States northward, and casually further south, migrating southward in winter.

Stations: Rock Harbor, Tamarack and arbor vitae swamps, I, 4. Siskowit Bay, Forest, V, 4. Washington Harbor, Forest, II, '04.

Resident: July 26.

Migration: August 22 to September 19.

This species was not common anywhere on the island and was rare at Rock Harbor. It was confined principally to the balsam-spruce forests and cedar swamps. At Siskowit it was often seen in the balsam-birch forest, being much more common than at either Rock Harbor or Washington Harbor. In all probability it nested on the island, but no nests or young were found. Even during migration it was uncommon and was usually found accompanying flocks of Chickadees, Golden-crowned Kinglets, or Red-breasted Nuthatches. Sometimes all of these birds would be found together.

104. *Sitta canadensis* (728). Red-breasted Nuthatch.

Range: North America at large, breeding from northern New England, northern New York, and northern Michigan northward; and southward in the Alleghanies, Rocky Mountains and Sierra Nevadas; in winter south to about the southern border of the United States.

Stations: Rock Harbor, Balsam-spruce forest, I, 3; Tamarack and Arbor Vitae swamps, I, 4; Edge of Ransom Clearing, II, 1; Tamarack swamp, II, 2; Border of Forbes Lake, II, 5; Conifers along trail to Sumner Lake, III, 4.

Siskowit Bay, Conifers along trail through Balsam-birch forest, V, 4; Tamarack swamp, V, 5; Arbor Vitae swamp, V, 8; Tamarack-spruce swamp, V, 11.

Washington Harbor, forest along river, II, '04; Tamarack swamp, V, '04; Conifers around camp clearing, I, '04.

Breeding: Young able to take care of themselves were seen throughout the season.

Migration: Last seen September 12.

The Red-breasted Nuthatch was quite common on the island, but was somewhat local in its distribution. The tamarack, arbor vitae, and spruce swamps were their favorite resorts, but they were often seen along the borders of the clearings where the conifers predominated. Practically all of their food was obtained on the various forms of evergreens.

105. *Parus atricapillus* (735). Chickadee.

Range: Eastern North America, north of the Potomac and Ohio valleys.

Stations: Rock Harbor, Natural rock clearings, I, 2; Balsam-spruce Forest, I, 3; Tamarack and Arbor Vitae swamps, I, 4; Benson Brook and Ransom clearings, II, 1; Tamarack swamp, II, 2; Forbes Lake, II, 5; Conifers along trail to Sumner Lake, III, 4.

Siskowit Lake, Trail through Balsam-Birch forest, V, 4; Tamarack swamp, V, 5; Outlet of Siskowit Lake, V, 9; West end of Siskowit Bay, VIII, '04.

Washington Harbor, Border of clearings, I, '04; Forest along river, II, '04; Tamarack swamp, V, '04; Washington Island, X, '04.

Breeding: On July 7 a nest was found with young and on August 10 a nest with 4 young.

The Chickadee was abundant throughout the island, but, except during the nesting season, it roamed about in small flocks from place to place, the conifers near camp being well populated one day, and the next day all would be gone. These small flocks were probably single families, or at most two or three families together. As soon as the young were able to leave the nest they commenced these local excursions and probably never returned to the nesting site except by chance. Their clear whistle mating song, "Péto," was heard throughout July and August and occasionally even in September. The Chickadees were often found in company with flocks of Red-breasted Nuthatches and Brown Creepers, especially as the migration season came on.

Breeding Notes: On July 7 a nest of the Chickadees was found in a hollow birch tree in the spruce and birch forest (I, 3). It contained several partially fledged young. Another nest was found August 10 in a dead birch tree about ten feet from the ground. The entrance was very small, there being scarcely room enough for two of the little ones to stick their small heads out at once. The parents flew to the nest with a moth or other small insect about once a minute.. Four young were found, but on the next day (August 11) they had left the nest and were seen sitting in a small balsam, their parents industriously feeding them.

106. *Regulus satrapa* (748). Golden-crowned Kinglet.

Range: North America generally, breeding in the northern and elevated parts of the United States and northward, migrating south in winter to Guatemala.

Stations: Rock Harbor, natural rock clearings, I, 2; Balsam-spruce forest, I, 3; Tamarack and Arbor Vitae swamp, I, 4; Sphagnum-spruce bog, I, 6; Benson Brook and Ransom Clearing, II, 1; Tamarack swamp, II, 2; Forbes Lake, II, 5; Conifers, III, 4.

Siskowit Bay, Balsam-spruce forest, V, 4; Tamarack swamp, V, 5; Arbor Vitae swamp, V, 8; Tamarack-spruce swamp, V, 11.

Washington Harbor, Border of clearings, I, 04; Conifers along river, II, 04; Tamarack swamp, V, '04; Washington Island, X, '04.

Breeding Notes: Nest partially completed July 7. It contained 8 eggs on July 21.

The Golden-crowned Kinglet was very common throughout the island,

usually occurring in small flocks of from fifteen to twenty. They were found wherever suitable conditions existed, namely, coniferous habitats, as balsam, spruce, tamarack, and arbor vitae forests and swamps. The birds were never shy, and were only momentarily disturbed by the discharge of a gun. Their song was one of the most common sounds of the forest, and is described in MCreary's notes as *tsee tsee-tsee-tsee.*

Breeding Notes: A pair of Golden-crowned Kinglets were seen July 6 with food in their mouth and giving every indication that they had young near. July 7 a pair was seen building a nest in a tall spruce. The birds were gathering the moss from the ground for nesting material. The nest was placed about 25 feet from the ground and was composed of green mosses partially lined with a white down-like substance. The site chosen was near the top of a small rocky hill where the forest was not very dense. The nest was nearly finished and was suspended from two limbs near the trunk of the tree. When next examined, July 21, it contained eight eggs. It was now composed of green ground moss, together with the long gray strands of the tree lichen, and was lined with fur from the Northern Hare. Its dimensions were four inches deep, and 4 inches in diameter, with a circular opening 1½ inches in diameter. In the balsam-spruce forest near camp we found a nest containing 6 young August 10. The structure was placed about thirty feet from the ground and five feet from the top of a tall, slender spruce. Both parents were carrying small moths and other insects to the young. This was a late nest, as young Kinglets had been seen early in July. The nest was suspended from a couple of small limbs, was composed of gray lichen and green moss, lined with Northern Hare fur, and was considerably larger than the nest previously described, the outside depth being about 6 inches.

107. *Regulus calendula* (749). Ruby-crowned Kinglet.

Range: North America south to Guatemala, north to the Arctic coast, breeding chiefly north of the United States, and in the Rocky Mountains, the Sierra Nevada, and the mountains of Arizona.

Stations: Washington Harbor, borders of clearings and forest, I, '04, II, '04.

Migrations: September 5 to 15.

The Ruby-crowned Kinglet was rather rare, especially if compared with its abundant relative, the Golden-crowned. A few were observed migrating on September 5. Both males and females were found in the little flock which passed slowly down the river, feeding on the insects about the alder bushes; small flocks, perhaps only families, as they seldom numbered more than five or six, were seen on the 7th, 8th and 9th. The birds were found again on the 12th, but this time they were much more common, and considerable flocks numbering twenty-five or thirty were seen. Only a few were seen on the 15th, the last day they were observed.

108. *Hylocichla fuscescens* (756). Wilson's Thrush.

Range: Eastern United States to the Plains, north to Manitoba, Ontario, Anticosti, and Newfoundland. Breeds from northern New Jersey and the northern part of the Lake States northward; winters sparingly in Florida, but chiefly south of the United States.

Stations: Rock Harbor, Spruce and Balsam Forest, I, 2-3; Sphagnum and Spruce Bog, st. I, 6; Along Benson Brook, II, 1. II, 4. III, 3. IV, 7.
Siskowit Bay, V, 4; Partial Clearing, II, 1.
Washington Harbor, Clearings, I, '04; Forest, II, '04.
Migration: August 24; September 14.

The Wilson's Thrush was very common on nearly all parts of the island, living in the balsam forests. This bird was first seen July 6 and was common throughout July and August. At Rock Harbor it was observed in all the balsam-spruce forests and was often seen along Benson Brook (II, 1) at McCargoe Cove (II, 4) and on the rock ridges near Sargent Lake (II, 3). They were also found among the birches and balsams at the west end of Rock Harbor (III, 3). It was occasionally seen in the birch forest near the head of Tobin Harbor (IV, 7) and at Siskowit Bay, V, 4.

109. *Hylocichla aliciae* (757). Gray-cheeked Thrush.

Range: Eastern North America, west to the Plains, Alaska, and eastern Siberia, north to the Arctic coast, south, in winter, to Costa Rica. Breeds chiefly north of the United States.

Stations: Washington Harbor. Clearings, I, '04. X, '04.
Migration: September 5, 12 to 21 when observations closed.

The first record was a specimen found dead at Washington Harbor on September 5. (X, '04). This was at the close of a heavy gale lasting since the first, and the bird had flown against a lighted window during the night previous. Many other species were killed at this same place during this storm, the lighted windows proving a much more fatal place during storms and on cloudy nights than during clear weather, probably because the birds fly lower on such nights. This specimen was killed on the north side of a pavilion. No others were seen until September 12, when in company with thousands of other migrants, it was very abundant in the clearings.

Large flocks were seen every day throughout the remainder of my stay, the border of clearings and the roadways being the places where they were the most abundant.

110. *Hylocichla ustulata swainsoni* (738a). Olive-backed Thrush.

Range: Eastern North America and westward to the Upper Columbia River and East Humbolt Mountains, straggling to the Pacific coast. Southward in winter to Cuba, Guatemala, Nicaragua, Columbia, Ecuador, and Peru. Casual in Bermuda. Breeds in the northern Alleghanies, the Catskills, the mountainous parts of southern New England, southern Sierra Nevada, and northward.

Stations: Rock Harbor, Beach at Rock Harbor, I, 1; Spruce and Balsam Forest, I, 2-3.
Partial clearing, I, 1, II, 1; Partial clearing along Benson Brook, II, 1; Rock Ridge clearings, II, 3.
Siskowit Bay, Forest, V, 4.
Washington Harbor, Clearings, I, '04; Forest, II, '04.

Breeding: July 8 nest with 3 young. August 3, two young just able to fly.

Migration: From about the middle of August to September 17.

The Olive-backed Thrush was a common breeder throughout the island

and was one of the most abundant thrushes during migration. The dense heavily shaded forest offered the most favorable conditions and except during migration it was seldom found in any other location. The damp places bordering streams were a favorite resort, the birds being usually found on the lower border of the balsam and spruce or among the decaying leaves and rubbish at their bases. Owing to the dense shade the lowest branches usually died and dropped off, so for a height of three to five feet it was relatively open. It was this rather open, yet heavily shaded condition which seemed to be best suited to these thrushes during the breeding season. They were also found in dense alder thickets and resorted to the border of the woods and the roadside during the migration.

Breeding Notes: On July 8 an Olive-backed Thrush's nest was found in the balsam-spruce forest at Rock Harbor (I, 3). The nest was situated on a horizontal spruce limb about five feet from the ground. The tree stood at the edge of a small rocky opening. It was placed about four feet from the tree trunk and was quite conspicuous. The nest was composed principally of dead grasses with moss and the long thread-like tree lichens woven in. Rootlets and leaves formed the lining. Three very young birds were found. Only one adult was seen and this one proved very shy, refusing to return to her young while being watched. During the forenoon the sunlight fell directly upon this nest, so exposed was its position at the edge of the rocky clearing, but in the afternoon it was shielded by a high wall of rocks about twenty feet distant.

On August 3 a female Olive-backed Thrush was found accompanied by two young just able to fly. They were feeding in a thicket of maple and mountain ash at the edge of a small clearing on one of the islands in Siskowit Bay.

111. *Hylocichla guttata pallasii* (759b). Hermit Thrush.

Range: Eastern North America, breeding from the northern Alleghanies, the mountainous parts of southern New England, southern New York, and northern Michigan, etc., northward and wintering from the northern states southward.

Stations: Rock Harbor, Balsam-spruce Forest, I, 3.
Siskowit Bay, Balsam Birch Forest, V, 4.
Washington Harbor, borders of clearings, I, '04; Forest near river, II, '04.

Breeding: A young bird was taken July 7.

Migration: August 22; September 14.

The Hermit Thrush probably breeds throughout the islands in suitable localities. No nests were found, but the immature specimen taken July 7 is probably a breeding record, as none of these birds were observed migrating until August 22. They were never abundant, but during part of the period were nearly as common as the Olive-Backed. The dense clumps of mountain maple were the favorite habitat.

112. *Merula migratoria* (761). American Robin.

Range: Eastern North America to the Rocky Mountains, including eastern Mexico and Alaska. Breeds from Virginia and Kansas northward to the Arctic coast; winters from southern Canada and the northern states (irregularly) southward.

Stations: Rock Harbor, Rock Ridge Clearing, II, 3.
Washington Harbor, Clearings, I, '04; Open Forest, II, '04; X, '04.

Breeding: July 11, nest with setting bird.

Migration: September 6 to 21 on. The residents reported large flocks in October.

This bird is rather rare, considering the island as a whole, but occurs in limited numbers wherever favorable conditions exist. The clearings, both natural and artificial, at Rock Harbor afforded suitable habitats, and at this place most of the Robins were found. At Siskowit they were reported by the light-house keeper as occasionally nesting on Menagerie Island and at the large clearing near the end of the bay (VII, '04) a few were observed September 9 and 10. These latter were probably migrating. They were regular nesters at Washington Harbor, the clearings and other changes brought about by the agency of man, furnishing conditions better suited to their needs than the balsam-spruce forest which covered the island. Our observations at this latter point were so late in the season that no nests or young birds were found, but the resident at the club-house (I, '04) and also on Washington Island (X, 04) reported that the birds nested at both places during the latter part of June. Only scattered individuals were observed at the club-house until September 6, when the real migratory movement commenced.

Breeding Notes: A nest with the female setting upon it was found July 11. It was situated in a small birch tree on the edge of a clearing on one of the rock ridges along the trail to McCargoe Cove (II, 3). The nest was placed about fifteen feet from the ground. Several pairs of these birds were observed at similar locations and probably nested wherever found.

113. *Sialia sialis* (766). Blue Bird.

Range: Eastern United States to the eastern base of the Rocky Mountains, north to Manitoba, Ontario and Nova Scotia, south in winter from the middle states to the Gulf States and Cuba.

Stations: Washington Harbor, clearings and burned area, I, '04.

Breeding: Found near nest August 18.

Migrating: August 22 to September 12.

The Blue Bird is a rare summer resident on the island. None of this species were observed during our stay on the island the year previous, and the few families which came to the clearing at Washington Harbor were the only ones observed throughout this season.

Breeding Notes: A nest of this bird was found in a birch stub near the edge of the third clearing. It was located in a Downy Woodpecker's hole about fifteen feet above the ground. On this date, August 18, the young had left the nest, but still kept in its immediate vicinity.

NOTES ON ISLE ROYALE MAMMALS AND THEIR ECOLOGICAL RELATIONS.

BY DR. CHAS. C. ADAMS.

I. Introduction.

The following notes on the mammals should be considered supplementary to those published concerning the collections made by the Museum party during 1904.* The specimens were largely collected by N. A. Wood and Max M. Peet, although others were taken by Dr. R. A. Brown, O. M'Creary and W. P. Holt. Unfortunately the ecological relations of the mammals could not receive the attention in the field which their importance deserved.

For the determination of all doubtful specimens we are indebted to: Dr. C. Hart Merriam, Chief of the Biological Survey of the U. S. Department of Agriculture; to Mr. W. H. Osgood and Mr. E. W. Nelson of the same survey; and to Dr. Glover M. Allen, of the Boston Society of Natural History, for the determination of certain bats.

In the references to the literature, no attempt has been made to cite all authorities for the ecological notes or those of geographic range, but enough are given to furnish an index to such literature as will be of special interest to the Michigan student.

Although Isle Royale is an almost uninhabited region, except for the summer visitors, yet its original condition has been modified in several important respects. Thus forest fires have at various times swept over large areas of the eastern half of the island, and trappers have exterminated the beaver and perhaps other species.

The location of the old trading posts is of interest because of their relation to mammal remains, such as antlers, which have been, and may be again found. Dr. Lane ('98, p. 3) cites the location of several of these posts and others are given on the U. S. Land Office map by Ives; these different posts were located as follows:

1. Near Washington Harbor, Sec. 2, T. 63 N., R. 39 W. American Fur Co.
2. Head of Siskowit Bay, Sec. 2, T. 63 N., R. 37 W. American Fur Co. Trading post and fishery.
3. On south shore of Siskowit Bay, Sec. 35, T. 64 N., R. 37 W. American Fur Co. Trading post and fishery.
4. Near Hay Bay, Sec. 24, T. 64 N., R. 37 W. Hudson Bay Co.
5. On the north shore of Fish Island, Sec. 35, T. 67 N., R. 34 W. American Fur Co. Trading and fishing post.
6. Near Card Point. (cf. Lane, '98, p. 3.)

It would be of considerable interest if the records of the fur companies could be examined for information bearing upon the original

* An Ecological Survey in Northern Michigan, 1906, pp. 131-133.

mammal fauna of the island. It is not unlikely that the Otter, *Lutra hudsonica hudsonica* (Desm.), was a member of this fauna; it would be more surprising if it were not. Near the east end of Todd Harbor there is an Otter Lake, but it is very difficult to determine how much reliability can be put on such place names, as evidence of the former occurrence of animals. The most notorious case in Michigan is that of the Wolverine (which may also have been a resident of Isle Royale), where in spite of the fact that Michigan is called the "Wolverine" State and there are such place names, yet no undoubted records of the occurrence of this animal are known. (cf. An Ecological Survey of the Porcupine Mountains and Isle Royale, p. 131.) In the present connection it is therefore of interest to note that there are several place names about the Isle Royale archipelago which have evidently been derived from the fauna, of which at least one member has become extinct. Reference is made to such names as Beaver and Caribou Islands and to Beaver Lake near the east end of Todd Harbor. Other animal place names worth mentioning in this connection are the following: Fish (island), Pickerel (cove), Angleworm and Chicken-bone (lakes, descriptive of their form), Hawk and Gull (islands). The abundance of pickerel, hawks and gulls upon Isle Royale make such names quite appropriate.

As almost nothing of a general character has been written on the mammals of Michigan, it has been thought desirable to depart from the usual form of an annotated list and include such brief ecological notes as could be secured from available literature, while the geographic data are intended to orient each species geographically.

The following is, so far as known, a complete list of the mammals recorded from Isle Royale:

1. *Rangifer caribou* (Gmelin). Woodland Caribou.
2. *Sciurus hudsonicus* (Erx.). Hudson Bay Red Squirrel.
3. *Castor canadensis* Kuhl. Northeastern Beaver.
4. *Peromyscus canadensis umbrinus?* (Miller). Isle Royale White-footed Mouse.
5. *Evotomys gapperi* (Vigors). Common Red-backed Mouse.
6. *Fiber zibethicus* (Linn.). Muskrat.
7. *Lepus americanus* (Erx.). Hudson Bay Varying Hare.
8. *Lynx canadensis* (Kerr). Canada Lynx.
9. *Mustela americana* (Turton). Eastern Marten.
10. *Putorius vison* (Schreber). Mink.
11. *Putorius cicognani* (Bonap.). Small Brown Weasel.
12. *Putorius noveboracensis* (Emmons). New York Weasel.
13. *Myotis subulatus* (Say). Say's Brown Bat.
14. *Myotis lucifugus* (Le Conte). Le Conte's Brown Bat.
15. *Vespertilio fuscus* (Beauv.). Brown Bat.

2. *Mammal Successions.*

While it was not possible to make a detailed study of the ecological distribution of the mammals yet a few relations seem evident which may prove suggestive to others. The succession of vegetation has long been recognized, as it was well known that burned forest lands will in time become invaded by herbaceous plants, later by shrubs, and finally by

a forest. Yet the fact that there must be similar animal successions has attracted but little attention and, so far as known to the writer, no definite attempt has even been made to determine mammal successions, much less to recognize the need of formulating its laws. Successions of vegetation initiated by man were recognized long before those in nature, but it seems that the students of animals have not only neglected "natural" successions but also even those influenced by man. *A priori* no one can doubt but that there must be mammal successions correlated with environmental changes upon which mammals are dependent. To resolve such a problem as this demands more than a recognition of the species involved and needs a knowledge of their life history, habits and their environmental relations. On account of the preliminary character of this work only a few suggestions will be attempted at this place.

As the level of the Glacial and post-Glacial antecedents of Lake Superior were lowered, Isle Royale began a new biotic cycle; from a reef in the lake it became transformed into an island. But the history of the island even prior to its emergence must be considered because the pre-Glacial topography and the overriding ice both left a record of their influence upon its surface in the form of parallel ridges and depressions. Thus the Isle inherited from the past certain characters which are conspicuous features of the animal environment even today. These irregularities of the surface produced rocky flats and ridges, or rock bound basins, which in all probability were thoroughly wave washed and cleared of soil as the waves fell from them. The inheritance of these depressions, rock surfaces and ridges, allows us to consider two sets of original conditions. That of the depressions with their lakes, ponds and swamps, and that of the ridges or rock surfaces with openings or "rock clearings." The first will be called the Lake-Pond-Swamp series.

1. *Lake-Pond-Swamp Series.*—From the large lakes upon the island all gradations of conditions are found leading to the forested swamps. The shore line of the island itself should also be mentioned in this connection as its conditions and mammal fauna in protected parts must be much like that of the larger lakes upon the island. To these marginal conditions must be related the Muskrat, Mink, and perhaps the Otter and the Beaver. All of these animals will traverse the open water but are more truly amphibious or frequenters of the margin. The dryer shrub or Cassandra zone is likely to be invaded by Hares, as is clearly shown by their numerous run-ways, while wandering Lynx, Mink and Weasels may also be expected here in search of their food, while the open area over the water and marsh are likely to furnish a flight area for bats. It should not be inferred, however, that these mammals do not occur in other conditions, but rather that they are representative or dominant forms in such an environment.

The dynamical relations of such conditions should be considered for their bearing upon the laws of environmental changes. With the falling of the Lake level the beach zone moves downward and is invaded by a land flora and fauna. This same change of level, supplemented by inwash, vegetable and animal debris, and possibly the down-cutting of outlets tends to drain basins and allow the encroachment of the open

marginal zone upon the open or deeper water. At the same time this marginal open zone, as a solid substratum develops, tends to become invaded by Tamarack, Black Spruce and Arbor Vitae, and still later by the balsam and white spruce forest. But while attention has only been directed to the conspicuous forest cover, it should be remembered that the entire environment, the water, soil, ground cover, light relations, animal foods, etc., are also undergoing a transformation.

Correlated with the invasion of the open swamp by the forest is the arrival of the Red Squirrel; while as the forest becomes denser and a shade develops under the trees conditions are produced which are favorable for the Red-backed Mouse. These forested swamps are likely to have a poor ground fauna, as the forms likely to frequent the open are greatly reduced in numbers or excluded, while the wet ground tends to exclude many forms of the balsam forest. But as these forested swamps become dryer, the balsam and white spruce tend to invade them and thus one is able to see all stages of transition, from the open water to that of the balsam-spruce forest. With regard to the mammal fauna, these relations may be briefly summed up as follows: from the open water to the balsam-spruce forest there is a relatively simple change, from the dominance of the aquatic and marsh types (supplemented by the bats) to land forms which are terrestrial, as the weasels, terrestrial and arboreal, as the Lynx, and arboreal as the Marten, and aerial as the bats which frequent the margins.

Let us now consider the second series, which begins with land rather than open water, and trace its general succession.

2. *The Land Series.*—As the lake level fell from the island, rock surfaces were exposed which surrounded the wet and damp depressions. In all probability these surfaces had but little soil, like the exposed wave-washed beaches of today. These flat rock surfaces and ridges have probably had quite different histories or successions from that of the depressions, although both were originally open, yet this was due to very different causes; in the case of the lake this may have been because a substratum was lacking, while on the rock surface there was no soil and hence the openings or "rock clearings." Thus bare or lichen covered rocks offer little that is attractive to mammals, although bats might take shelter here during the day under loose rocks, and patrol the open at night; yet it is not until there has been an accumulation of soil in the crevices, so that the Bearberry, Pennsylvania Cherry, Cladonia or scattered Jack Pines get a foothold, that the Varying Hare, Red Squirrel and Caribou can find their food here. In turn comes the Lynx, Weasels and perhaps the Marten in search of the vegetarians. Here again the Bats, Red Squirrel, Hare and Lynx are pioneer mammals invading open unforested areas. As the soil increases in depth on such surfaces, a bordering zone of Aspen and Birch spreads over the surfaces and slopes in a manner similar to the encroachment of the sedge zone upon the open water of a lake, and tends to restrict the open areas. These in turn are followed by a zone of Balsam and White Spruce, so that in time these surfaces tend to become completely forested, just as the depressions tend to have a similar fate. With these forests comes the exclusion of the bats, while the Red Squirrels increase, and the Hare tends to frequent the forest

margins, where many go to feed in the openings at dusk. With the dryer substratum and more diversified vegetation the conditions are evidently more favorable for the White-footed Mouse, which with the Squirrels and Hares become dominant forms, and prove attractive to Weasels, Marten and Lynx. These mammals are the representative balsam-spruce forest types; and it is not improbable that if such a forest becomes transformed into a maple-yellow birch type, the character of the mammals but little changed, with the possible exception of the relative abundance of some species.

Briefly summed up, the general succession of mammal types—from the "rock clearing" to the balsam-white spruce or hardwood forest—is thus seen to be a change from the dominance of the forms frequenting the open to those of the forest. The final result of both the lake and the land series is thus seen to be practically the same—both lead to the dominance of the forest types. Such observations and influences, which attempt to correlate environmental changes with the habit and habitat relations of the mammals, point to a general conclusion which should prove useful in field work: that each habitat, swamp, conifer or hardwood forest, etc. should not only be considered as a unit of environment, but even more—*as parts of a series of changes or stages in the continuous development of the animal environment.* Standing upon the top of the Greenstone Range, one may see this entire series of conditions, varied, to be sure, and confusing to many, yet in many ways relatively simple and free from chaos.

3. *Faunal Affinities and Migrations.*

1. *The Geographic Affinities of the Fauna.*—As determined by the present geographic range of the species and varieties of mammals found on Isle Royale, the fauna is emphatically of the northeastern biotic type (Adams, '05, p. 58). This is the dominant fauna of the region from Labrador westward, between Hudson Bay and Lake Superior into the Mackenzie basin, and only enters eastern United States to a limited degree, except on mountains. The representative forms are: Caribou, Red Squirrel, Beaver (typical form), White-footed Mouse, Red-backed Mouse, Hare, Lynx, Marten and the Small Brown Weasel. In case these forms range westward into the Rocky Mountains and to the Pacific Coast, they are represented by another variety, except in the case of the Lynx. The Muskrat, New York Weasel, Mink (typical form) and Say's Brown Bat are forms ranging far into southeastern United States, some reaching west to the Rocky Mountains or the Pacific Coast. Le Conte's Brown Bat and the Brown Bat have such extensive ranges to the south of the United States as clearly to suggest a dispersal from the south.

To determine close faunal affinities, much weight must be given to the geographic range of the varieties or forms whose affinities are to be determined. In a region whose fauna has undergone extensive migrations, within comparatively recent times, as in the case of glaciated North America, many allied varieties have had a very different history and such forms must be subordinated in the faunal comparison to those that have had similar histories. For this reason the post-Glacial migrations of the fauna of eastern North America make the north and south relations stronger than those between the east and the west because there

is a closer genetic relationship between forms along the same general migration route than between those of very distinct routes and histories.

2. *Post-Glacial Origin of the Fauna.*—The geographic affinities of the mammal fauna of Isle Royale have been shown to be with those of the region north of Lake Superior, and representative of the coniferous forest region of central and eastern Canada. There now remains to be considered the approximate post-Glacial geographic origin of this northern fauna. But before this subject can be understood, special attention should be directed to the fact that an extensive barrier in the form of a series of Glacial and post-Glacial lakes and even the Champlain Sea (cf. Taylor, '05, pp. 103, 106 and 107) stood between the advancing fauna from the south and Canada. All these barriers were not contemporaneous, yet some of them, generally several extensive ones, have been present since the decline of the Wisconsin ice sheet. This barrier was only interrupted, as far as many mammals have been concerned, by narrow streams, such as, the Saint Clair, Detroit, Niagara and St. Lawrence rivers. Even these must have retarded many forms, except during the winter, if they were not amphibious or flying species. The significance of this barrier seems to have been generally overlooked, but a moment's reflection will show its important influence upon the post-Glacial origin of the biota of eastern Canada.

On account of the presence of the ice sheet on both sides of Hudson Bay, and its longer duration at the Labradorian center, we may safely dismiss the question of the fauna under consideration as being of immediate northern origin. On the other hand we have much positive information which shows that there were centers of preservation of biotic types south of the ice margin in the United States. For these reasons our problem becomes one of tracing the probable northern and perhaps eastern migration routes from these centers of preservation to the region vacated by the retreating ice sheet.

Therefore, keeping in mind the major interruptions of the water barrier and the faunal affinities of Canada east of the Great Plains, it appears that the major routes into Canada have been, in the east, up the Hudson and Champlain valleys, along the Appalachian range up the Hudson and Mohawk valleys and thence around both ends of Lake Ontario—routes for the coastal and Appalachian types. The Ohio valley types invaded Ontario around both ends of Lake Erie, especially some of the more recent southern and Mississippi forms, around the western end. Perhaps a limited number of western forms have entered Ontario through the Upper Peninsula of Michigan and a very large number of Mississippi valley, and to a lesser degree western types, around the western end of Lake Superior. The Mackenzie basin seems to have been invaded largely up the Mississippi and down the Red River valleys, the Plains also sending their quota. These routes are largely shown by the affinities of the present biota and have in all probability functioned throughout post-Glacial times, because there have been no marked changes in the major routes, with the exception perhaps of the drainage changes which have influenced the fresh-water life. With such general relations in mind, we are in a position to consider the geographic origin of the northern Ontario fauna.

In considering the post-Glacial invasion of northern Ontario from

the southern centers of preservation, it is evident that the barren ground types must have traversed this region en route to the northern position which they now occupy. But relicts of this type have not been recognized among the mammals, although it seems very probable that some invertebrates have lingered. Miller ('97, pp. 6-8) evidently considers that the exposed north shore of Lake Superior, shows marked Hudson Bay affinities, but is not able to decide whether or not this area is limited to the Lake coast. Of the five mammals which he lists as showing these northern affinities, only two, the Caribou and White-footed Mouse, occur on Isle Royale. Miller evidently did not recognize any barren ground relicts in the fauna, yet its Hudsonian affinities may belong, in part, to this class. The barren ground relicts, when present in the coniferous forest belt, may be expected to occur in open swamps, talus or other open rock areas or habitats, as these conditions will most nearly approach those of the open barren grounds.

With the amelioration of the glacial climate, the barren ground forms were replaced by an invasion of the stunted tree growth and its associated fauna. The coniferous forest association, in all probability, invaded the north shore region, not only around the western end of Lake Superior but also from the east, where it lingers even today as a dominant type upon the higher mountains, thus preserving a continuous record to the present day; while to the westward this type has not lingered so far to the south because of the absence of favorable mountain habitats. On account of the present great extent of this biotic type in the east, a more rapid northward extension may have taken place there, but the mountainous character of the country, the various water barriers westward to Niagara, and possibly the longer duration of the ice in the northeast may have retarded this advance, so that a relatively more rapid extension took place from Michigan into southwestern Ontario and around the western end of Lake Superior (cf. Taylor, '05, p. 107, map). It therefore seems quite probable that the north shore region was invaded both from southern Ontario and from around the western end of Lake Superior.

Returning now to the immediate origin of the Isle Royale mammal fauna, it is quite evident that with the exception of the bats, this fauna reached the island from the north shore of Lake Superior. There is perhaps another possibility, but one which seems highly improbable, and that is, that the island was stocked from the south shore of the Lake at that time during post-Glacial migrations, when it contained a more boreal type of fauna. But when we consider the fact that the Superior basin since Glacial times has had much the same general form as the present lake, it seems probable that lake currents similar to those of the present lake existed, and under such circumstances the north shore fauna, especially to the eastward, would be favored. The ice bridge between the island and the north shore permits direct communication with that shore during the winter. The method of arrival for various mammals must of course remain largely conjectural, but the following methods seem probable; the bats by direct flight; the Caribou, Hare, Lynx and Marten probably over the ice; the Red-backed and White-footed Mouse, Red Squirrel and perhaps the Weasels by means of drift-wood and lake currents; the aquatic forms, Muskrat, Mink, Beaver, and perhaps Otter, by swimming.

4. Annotated List.

1. *Rangifer caribou* (Gmelin). Woodland Caribou.

Many reports are in circulation concerning the occurrence of Caribou upon Isle Royale, and yet I have learned of but two records in the literature, and these refer only to antlers. Baird ('57, p. 634) figures, from the Smithsonian Collection, an antler from an adult Caribou from Isle Royale (No. 900), and Gillman ('73, p. 751) gives the following information: "During a recent visit (May, 1873) to Isle Royale, Michigan (Lake Superior), interesting evidence of the former presence of the Caribou (*Rangifer caribou* Aud. and Bach.), long extinct there, was brought to my observation. I have now in my possession two relics —the greater parts of the horns of this animal—which were picked up at different points on the island. The antlers are much decayed, one being a mere shell, and besides, they had been gnawed by rodents. Such specimens, often of great size, are frequently discovered of late at this isolated place."

Mr. Gillman has recently written to me that these antlers were many years ago presented to Columbia College. But upon inquiry, it seems that it is not possible now to find them.

Dr. A. C. Lane, State Geologist of Michigan, sends me the following records from his Isle Royale note book: "Note book 115, p. 72, September 25, 1895. Forbes found a Caribou horn 2½ feet long."

On account of the limited information on this subject I was therefore pleased to secure the following observations from the men who had only recently seen the live animals upon the island. Two trappers, Victor Anderson and his son, John, spent the winter of 1903-1904 trapping upon the isle. On March 27, 1904, John Anderson saw two Caribou at Blake's Point, on the northeast end of the island, and on the same day his father drove two Caribou, on the ice, from the head of Rock Harbor eastward to the outlet of the Harbor near Middle Islands. These two Caribou were very tame, so that Anderson, who had no gun, was able to get within about 200 feet of them. Anderson said that at this time the island was connected with the mainland, on the north, by ice. On April 16, 1905, Anderson, his son and several fishermen saw 9 Caribou on the ice in the channel near their fishing camp on Rock Harbor near the Light-house. At this time the lake was open but Rock Harbor was still frozen over, as the ice remained in the harbor for some little time after the ice broke up in the lake. These facts clearly indicate that Caribou must have been upon the island during the past summer, and the following observation tends to substantiate this inference. On September 9, 1905, Michael Hollinger, an experienced trapper, and Max M. Peet, of this expedition, saw, about four miles out from Washington Club, on the Desor trail (III, '04) a small bunch of low maples which had been broken down, the branches, bark and leaves stripped off, and the small branches eaten away. The work was fresh, as the leaves were only wilted, and the exposed wood was not discolored. Hollinger was confident that this was the work of the Caribou.

The following information, which was reported to me by Mr. J. H. Malone, Keeper of the Menagerie Island Light on Siskowit Bay, is

suggestive for its bearing on the question of the origin of the Caribou upon the Isle. John Erickson was fishing through the ice, about 5 miles out from Pigeon Point, Minn., and at one time saw 11 Caribou on the ice in the direction of Isle Royale. This clearly suggests a satisfactory method by means of which these animals could easily reach the island.

Ecological Notes.—According to Canton, Caribou frequent marsh and swamp grounds, a characteristic which is in decided harmony with the physical conditions of the area it inhabits. It is adapted to these conditions in several ways, as is shown not only in its feeding upon plant life and frequenting damp and wet places, but also in the character of its feet. Caton ('77, p. 90) says: "In traveling through the snows, or soft marshy ground, the Caribou throws his hind feet forward, so as to bring the leg into something of a horizontal position, spreads wide his claws, and broad accessory hoofs, and thus presents an extraordinary bearing surface to sustain him on the yielding ground, and so he is enabled to shuffle along with great rapidity, where any other large quadruped would mire in a bog, or become absolutely snowbound. The Reindeer [Caribou] alone leaves in his track the marks of all four of his hoofs belonging to each hind foot, and specimens show the effects of attrition on these secondary hoofs, and prove that they serve a useful purpose in the economy of the animal." Still another adaptation is of interest. During winter, the frog of the Caribou's hoof is entirely resorbed (Elliot, '02, p. 268), thus producing a sharp rimmed concave surface well adapted for walking upon the ice.

In addition to the swamp plants used for food, the branches and leaves of trees are frequently eaten, but the characteristic food is the "reindeer lichen or moss" (*Cladonia*). This lichen is very abundant on Isle Royale where the soil is too shallow and physical forces too severe for most other plants to grow, as on the south shore of the island(V, 2) and upon the ridges. These lichen growths are very characteristic of the area over which the Caribou ranges in Northeastern North America. The region has been so recently glaciated and the soil removed so that extensive patches of these lichens occur scattered through the forests and are as characteristic of the region as are its swamps and coniferous forests. This kind of food is therefore of general occurrence throughout its geographic range.

The female Caribou is remarkable in the possession of antlers, a characteristic in the deer family, as a rule, of males only; they are, however, much smaller in size than those of the male. Caribou antlers are further remarkable for their variety of form, the antlers from the same individual, according to Caton ('77, p. 89), having as little in common as those from different individuals. The old males, as a rule, shed their antlers annually before the last of December, but the young males retain them longer, the yearlings till spring and the females still later, until after the young are born.

The breeding season, according to MacFarlane ('05, pp. 679, 678) occurs in September and October, and the young, one or two, are born the following spring.

The migration habits of Caribou are of considerable interest and may have an important bearing upon the differentiation of the Woodland and

Barren Ground, *R. arcticus* (Rich), forms. In the vicinity of York Factory on the west coast of Hudson Bay, the Woodland Caribou (Preble, '02, p. 41) migrates to the coast in the spring and returns inland about the middle of October and during November. In addition to this summer seaward migration of these coastal ones, there is also a summer southward movement to the interior (Georgeson, '04, p. 378). At least some of the more northern Barren Ground Caribou during the summer also migrate to the coast near Hudson Bay as well as near the mouth of the Mackenzie River (MacFarlane, '05, p. 681), and inland, at Reindeer Lake, Keewatin (MacFarlane, '05, p. 684), there is a distinct northward spring migration during the last of April and May, and a return movement during late October, November and December. The breeding season is during September and October, and as this period is much the same for the two forms, the northward migration of the Barren Ground Caribou and the southward migration of the Woodland Caribou, has a distinct tendency to isolate these two types during their early fall breeding season; a result which in time would certainly influence their specific differentiation. Similar relations in the past may be one of the causes for the differences which are today recognized. MacFarlane ('05, p. 680) states that the two forms do not associate. The seaward migration is probably limited to those in the vicinity of the coast and does not influence the inland forms to a marked degree. These seasonal migrations are very suggestive of the influence which climate, and, in part, the resultant habits, may have upon habit and specific differentiation.

Geographic Range.—The Woodland Caribou ranges northward, in forested regions, from Labrador, Nova Scotia, and Maine, (formerly northern New Hampshire and Vermont), on the east, westward through Quebec and Ontario along the north shore of Lake Superior, where Miller reports it very abundant, (Isle Royale) Michigan; northern Minnesota; Manitoba; Saskatchewan (Cumberland House) to Athabasca, and Great Slave Lake, Mackenzie (cf. Grant, '02, p. 18).

Aside from the Isle Royale records, the only other record of the occurrence of Caribou in Michigan is that given in Caton ('77, p. 87) whose statement is as follows: "If it was ever abundant south of Lake Superior, where it was found when the copper and iron mines first invited extensive settlements there, the fact is not well attested, and I cannot learn that any have been met with south of that Lake within the last twenty years or more."

Fossil reindeer remains have been found in a number of Pleistocene deposits, far to the south of their present range (cf. Hay, '02, p. 686) and clearly show that they formerly occurred in New York, New Jersey, Pennsylvania, Kentucky and Iowa. The extreme southern localities may be due to southern winter migrants. It is not improbable that among these fossil remains, several forms occur, as even today the ranges of the various forms are not sharply defined, and as our knowledge of the recent species has been greatly extended in recent years, these fossil remains are in need of critical study. Fossil Caribou are of special interest on account of their bearing upon the Glacial and post-Glacial dispersal of these animals. These facts clearly suggest an extensive migration from the vicinity of the glacial border northward into the barren grounds.

As the Woodland Caribou, even in its migrations, tends to remain near the forests, their fossil remains may furnish valuable suggestions concerning the southern extension of forests during the Ice Age.

2. *Sciurus hudsonicus* (Erx.). Hudson Bay Red Squirrel. The Red Squirrels were exceedingly abundant, especially in the coniferous forests. The Squirrels, Hares, White-footed Mice and Lynx are the representative mammals of the island. The most conspicuous as one walked through the forest were the Squirrels, whose abundance and persistent barking repeatedly attracted attention. A total of 40 specimens was secured from the following localities: I, 1, 2, 3, 4; II, 5; V, 2, 3, 4, 5 and I, '04. They were seen or heard at or near the following additional places: I, 5; III, 2; IV, 9; V, 7; I, '04 and II, '04. Only a few of the details of occurence will be given. Squirrels were abundant in the forests about the Light-house at Rock Harbor (I, 3) and along the path to the fishing camp; also fairly abundant on the Jack Pine ridge on the north side of Conglomerate Bay (I, 5), and in the woods about the margin of the Sphagnum-spruce bog (I, 6). They also occurred in the hardwood forest at the top of the Greenstone Range (IV, 9), near the head of Tobin Harbor. Along the Haytown trail, north of Siskowit Bay (V, 7), they were apparently not abundant, in fact very few birds or mammals were seen along this trail, and the forest was noticeably silent and in marked contrast to the forest at other places. The small heaps of bluish cone scales of the Balsam were several times seen marking the place where a squirrel had taken its meal. Our camp at Siskowit Bay (V, 3) was surrounded by a balsam- spruce forest, which fact explained the abundance of squirrels at this place. Much the same general conditions prevailed along the trail to Siskowit Lake (V, 4) where they were also abundant. At Washington Harbor, along the road to Wendigo (I, '04), squirrels were very abundant, particularly young ones.

Ecological Notes.—MacFarlane ('05, p. 749) states that this squirrel "makes its nest in a tree and has usually, once a year, from four to six, and occasionally as many as seven young." Merriam ('86, p. 218) states that in the Adirondacks of New York the young Red Squirrels are born about the first of April. On Sept. 17, 1905, Max M. Peet saw a squirrel about 20 feet above the ground, tearing away loose bark from a birch tree and carrying it away, presumably to be used in the construction of a nest.

Only a few observations were secured upon the food habits. While fishing for trout in the outlet of Siskowit Lake, Mr. K. Neutson saw a Red Squirrel running with a mushroom in its mouth. Max M. Peet also saw young squirrels eat similar fungi at Washington Harbor. He further reported that traps baited with nuts (hickory, peanut and walnut) did not prove attractive to them. Along the Wendigo road (I, '04) at Washington Harbor I saw a young squirrel examine some very low red raspberry bushes, evidently in search of berries. It secured one and stood up to eat it, but dropped down and approached within a few feet of me its curiosity momentarily getting the better of its hunger.

Notes on the Specimens Collected.—This series contains both young and adults collected during July and August of 1904 and 1905, and includes two specimens taken in winter pelage by a trapper. In all there are 52 specimens, 40 of which were taken during 1905. An examination

of these specimens brings out some interesting relations regarding the seasonal moults of pelage and its consequent color changes. These changes, as they occur about New York City, in the Southeastern Red Squirrel (*S. hudsonicus loquax* Bangs), have been studied by Allen ('90). This is the common Red Squirrel of Southern Michigan. The characteristic differences between the winter and summer pelages may be briefly stated thus: The winter pelage (from Michigan specimens), as a rule, is long and dense, with a bright rufous median dorsal band, very conspicuous ear tufts, body without distinct lateral black stripe, lower parts of body grayish white, sides of body yellowish olive, and soles of feet furred; the summer pelage is short, lacks the conspicuous rufous median band, the ear tufts, and the fur on the soles. It acquires a very distinct lateral black line, the lower parts are whitish or yellowish, and the upper parts suffused with rufous.

The spring moult, according to Allen, begins in April or May and is nearly completed during June and July. By the fall moult, a winter pelage is acquired during the months of November and December. This undergoes slight change, with the possible exception of an increasing intensity of the broad rufous band during February and March. The gradual character of these changes suggests that this process may be an almost continuous one.

A few specimens taken near Ann Arbor, Michigan, early in November, show the transition from the summer to the winter pelage. In some specimens the ear tufts are becoming prominent, the rufous on the tail is becoming intensified and is moving forward along the mid-dorsal line. One specimen (No. 32991) taken November 17, 1905, has but few long hairs upon the ears but has a very broad intense rufous dorsal band, a distinct black lateral line and is white below. Another (No. 33000), taken December 2, 1905, has the dorsal rufous band, well developed ear tufts and lacks the lateral black line. It seems probable that the time of spring moulting will prove to come during April and May, as in New York, but specimens are not available by which this can be determined for southern Michigan.

Turning now to the Isle Royale specimens some interesting differences become evident when the winter pelage is compared with that of similar specimens of *S. hudsonicus loquax* from Michigan. Unfortunately there are only two specimens in winter pelage from Isle Royale, and one of these skins (No. 32138) lacks ears and feet. The other (No. 33066) was taken early in January, 1904; both were collected by trappers. In these specimens the dorsal rufous band is only slightly developed, about to that degree of general rufous suffusion seen in summer specimens of *S. hudsonicus loquax* from southern Michigan. The difference between the two forms is very striking when they are placed side by side. In one specimen of *hudsonicus* the ear tufts are barely developed, and in both specimens the lateral black stripe is indistinct; the lower parts are dirty white or plumbeous; sides of the body olivaceous gray and the pelage long. In one the soles are densely furred. The summer pelage of *hudsonicus* apparently retains the rufous median stripe as in winter but is somewhat obscured by the general rufous suffusion of the upper surface, the amount of rufous having been increased on the sides; the ear tufts are, of course, lacking; the lateral

stripe becomes black and conspicuous; lower parts whitish or yellowish; above olivaceous or suffused with rufous but much paler than *S. hudsonicus loquax* in the corresponding pelage, soles bare, and the pelage short. A few immature specimens (Nos. 33072, 33074, 33076, 33078) taken between July 27 and Aug. 11, are quite as gray as the January specimen, the lateral black line and the under parts corresponding closely to it. An adult male (No. 33050) belongs in the same category but is even more gray than either winter skin. The amount of fur on the soles is perhaps the most marked seasonal change with such specimens. In other words, the seasonal color changes are not well developed in some specimens.

It is evident from the above observations that, if the two winter specimens are representative, the seasonal color changes are much less pronounced in *hudsonicus* (some individuals,. in all probability, hardly changing in color at all) than in *S. hudsonicus loquax*. This of course does not mean that there are no moults, but that moulting is not accompanied by a marked color change. Such observations also suggest that the Red Squirrels, in the northern part of their range, may not show as marked seasonal color contrast as is seen farther to the south. But this point can only be definitely determined by the aid of a larger series of winter specimens than are at present in the Museum collection. From a somewhat different point of view, Allen ('98, p. 253) remarks "All the forms of the *S. hudsonicus* group present two well-marked phases of individual color variation, particularly in the summer pelage, namely, a rufous phase and an olivaceous phase, the former usually predominating in about the ratio of 4 to 3, with a considerable proportion of intermediates, which connect the two principal phases. The two principal phases are usually so well marked that were they separated geographically, it would be natural to regard them as subspecies. For this reason a small series of specimens from a given locality is apt to be unsatisfactory."

Allen's law of the increase of intensity of color from the north southward is well illustrated by the Red Squirrels in Michigan. The paler form, *S. hudsonicus,* occurs to the north, on Isle Royale, and the brighter, more rufous forms *hudsonicus loquax* to the south, in the remainder of Michigan. It is also worthy of note that the seasonal contrasts in pelage are apparently less marked in the northern than in the southern part of the State.

Geographic Range.—The typical form of the species has an extensive northern transcontinental range from Labrador, New Brunswick and Vermont, westward to the north shore of Lake Superior in Ontario; Isle Royale, Michigan; North Dakota; Manitoba; Mackenzie basin to Alaska and the Pacific Coast.

This extensive geographic range in the Canadian forested region and in Alaska is of special interest. The far northern range of this form and its great abundance suggest that it is well adapted to the region it inhabits. It is evidently a Glacial or post-Glacial migrant into most of its present northern range, as the entire area (excepting part of Alaska) lies within the region glaciated by the Wisconsin ice sheet. It seems probable therefore that, at the time of the maximum extension of this sheet, this squirrel frequented largely the coniferous forests at its south-

ern border—east of the Rocky Mountains—and as this sheet retreated northward it spread with the forests into the area now occupied. It also seems likely that their main headquarters were in the region south of the Great Lakes and eastward, because the probable aridity of the Great Plains in Glacial times would be unfavorable to extensive forest growth. The Glacial and post-Glacial migrations of the Red Squirrels, as far as they can be inferred, may explain some of the peculiarities of their present range. The Red Squirrel is a representative member of what I have elsewhere called the Northeastern Biota (Adams, '05), some of whose members have, in Glacial and post-Glacial times, invaded the glaciated region from the south and have spread northwest to the Pacific coast in Alaska as well as eastward, in Labrador, to the Atlantic coast.

It also seems probable that the geographic isolation and the peculiarities of the Black Hills Red Squirrel (*S. hudsonicus dakotensis* Allen) may be explained, in part, if it be considered a glacial relict which has become isolated by the change of climate attending the decline of the Ice Age. The incomplete development of the lateral black line, which usually occurs in the summer pelage of this group, is of special interest in this connection.

In addition to the typical form there are 9 or 10 varieties of this species which have a range from southern Alaska to Washington, Oregon, Idaho, northern Utah, Montana, Wyoming, South Dakota, southern Minnesota, Wisconsin, northern Illinois, Indiana, southward to North Carolina and northward to Labrador. The Red Squirrels are doubtless one of the best groups of North American mammals for a study of the laws of geographic variation, and is a group of undoubted Mexican or Central American origin (cf. Coues & Allen, '77, p. 670); the Isle Royale form being the one which has departed the fartherest from its region of origin. This species, judging from its geographic range, has apparently crossed the Rocky Mountains from the east, perhaps near the Canadian boundary.

3. *Castor canadensis canadensis* Kuhl. Northeastern Beaver. In all probability the Beaver is extinct upon Isle Royale, although it formerly occurred there. We saw no one who had any recent information of its occurrence. Mr. J. H. Malone, reported that a Mr. Butterfield had seen a beaver dam on a creek at the head of Hay Bay in 1878. About that time Mr. Malone found beaver cut stumps and remains of a dam on the short stream which forms the outlet of Siskowit Lake. The U. S. Land Office map indicates the site of "old" beaver dams as follows: SW. 1/4 Sec. 13, T. 64 N., R. 38W. NE. 1/4 Sec. 15, T. 64N. R. 37W. and NE. 1/4 Sec. 9, T. 63 N., R. 38 W. The Survey furnishing the data for this map was made by Wm. Ives in 1848.

Ecological Notes.—The Beavers of Michigan have been given more study than any other native mammal found in the State, and at the same time they have perhaps contributed more toward our knowledge of the natural history of the American species than those from any other locality. The extensive and important investigations referred to were made in Marquette County about 50 years ago by Lewis H. Morgan, and were published in 1868 in his volume entitled "The American Beaver and His Works." This publication, to which reference should be made

for a detailed account of the habits and activities of this animal, has become a classic in American natural history.

In brief the life history is as follows: The breeding season, according to MacFarlane ('05, p. 742), occurs in January and February, at which time the males fight fiercely. The young, blind at birth, are born during April and May, and are suckled for several weeks, but soon begin to eat the succulent stems and roots of plants. The young are believed to remain with parents for 2 or 3 years, and to breed at about the age of three. They are most prolific at about middle age, when they usually produce from 4 to 6 at a birth, and occasionally even 8 or 9. The Indians believe that they reach the age of 12 to 15 years (Morgan, '68, p. 222). There is a tendency for beavers to migrate (Morgan, '68, p. 137), especially when a region becomes overstocked, and very naturally they follow the streams.

Their food consists of roots of grasses and water plants, including the water-lily, the bark of aspens, fresh willow branches, birch, the leaves of deciduous trees, and late in winter even of wood itself. The winter supply of food is stored under water. The burrows, lodges, dams, and meadows that result from the activities of this animal have aroused much popular interest, but space can not be allowed to describe these in detail. There is a very extensive literature devoted to this phase of beaver life. The Beaver is essentially a burrowing animal, so that the margins of the waters which they frequent contain numerous burrows or tunnels. These are from 10 to 15 feet long and open, at the lower end, a foot or so below the water; from this point they incline upward to within a few inches of the surface of the ground, thus allowing for the necessary ventilation of the burrow. Morgan reports that in the case of the river-inhabiting beavers the upper ends of these tunnels are occasionally indicated by a pile of cuttings a foot or so high, and that it is probable that from such a beginning as this beaver lodges have been developed. Of these lodges there are several modifications, but their essential features are a burrow with submerged entrance, which leads upward into a chamber above the surface of the water. As a rule these lodges are located on the bank a few feet back from the water, but they also occur at the margins of streams or lakes, and within the ponds made by the dams. It is very evident that all of these lodges are but variations of the same fundamental plan.

The beaver dams excite much interest, and the completed dams may be quite extensive affairs as some are even several hundred feet long and over 6 feet high, causing the submergence of many acres of land. But it should be borne in mind that such feats are not the work of a single pair or family, but are the results of generations of industrious beavers. These dams are begun on a small scale, in all probability by a single pair or family, and in the course of time each generation contributes its share toward the repair and extension of the dam, so that in time it may become a very composite structure and perhaps of great extent. The dams, like the burrows and lodges, are built upon a simple plan, and susceptible of much modification in different conditions. Thus on small streams according to Morgan, where the banks are ill defined, the usual form of dam is one composed of sticks and poles, whose upper or water face is reinforced and plastered over with earth, stones and

sod, while on larger streams or where the banks are well defined with a deep channel and uniform current, the stick and bank work becomes buried and obscured by the large amount of earth, mud and stones composing it. In order to understand the utility of these dams and the resulting ponds, it is necessary to recall the fundamental burrowing character of the beaver, whose burrows and lodges require a submerged entrance, whose winter food must be stored in the bottom of these ponds, the protection thus afforded as a retreat from enemies; and there is yet another important relation which remains to be considered. In a large part of Northeastern North America a marginal zone of floating vegetation, bordered by tamaracks and spruces, tends to line the banks and margins of such streams ponds and lakes as are frequented by beavers. But these conifers are not only unavailable for food, but form a barricade between the water and the hardwoods, aspens, birch, etc. (the food of the beaver) which occupy the higher ground. A further disadvantage of this zone of plant life is that it is very unstable, often even floating, and furnishes no solid ground for burrows, which are the final retreats of the beaver when in danger. Thus the formation of a dam, and the consequent drowning of this unfavorable zone of plant life, tends to bring the water's edge nearer to the hardwoods and solid ground. But to credit all these advantages to the beaver's intelligence is unnecessary because the habit of building dams is of greater geographic extent than these marginal conditions. It seems more probable therefore, that such a habit has proved to be of special advantage under such conditions, rather than that these conditions have developed the habit.

The beaver meadows are grassland areas, sedges largely, which invade the shallow water and tend to replace the bordering conifers drowned out by the formation of the dams. Such grasslands may be quite extensive, and even occupy many acres, but such results are only secondary products, as far as the beaver's needs are concerned, for although the grass stems and roots are eaten to some extent and may be useful in plastering over their houses and in repairing the dams, yet they are apparently not essential features in their economy.

Geographic Range.—The typical form of this species has a range throughout northeastern North America northward to the tree limit from New Brunswick; Maine; New York; Quebec; Ontario; Michigan; Idaho; Mackenzie (Ft. Simpson); Alaska Peninsula and Yukon Valley and Alaska.

There are three geographic varieties ranging south of the Canadian or typical form; one in southeastern United States; another in the Rocky Mountains, and the third on the Pacific coast. Pleistocene beaver remains have been found in New York, Pennsylvania, New Jersey, Virginia, Tennessee, South Carolina, Ontario and Oregon. It is thus seen that for the species as a whole, these fossils do not indicate a range in Pleistocene times materially different from that of the present time.

The Glacial or post-Glacial extension of range of the Canadian Beaver, from the Atlantic Coast to the Pacific Ocean in Alaska and north to the tree limit, is a range much like that of the Hudson Bay Red Squirrel, and suggests a somewhat similar history. The great development of beavers in this northern region appears closely related to the physical

conditions brought about by baseleveling and glaciation—the poor drainage, as shown by the innumerable swamps, ponds and lakes and their small and sluggish streams.

In addition to the great abundance of the food plants there is the further favorable physical condition of deep snows, which fall before the soil or ponds freeze to a great depth, and thus make conditions favorable for beavers on account of the protection afforded from deep frost, which may close up the entrances to their burrows, houses, etc.

4. *Peromyscus canadensis umbrinus?* Miller. Isle Royale White-footed Mouse. This mouse was perhaps the most abundant mammal upon the island. It occurred in a great variety of situations as is indicated by specimens taken at the following stations; I, 3, 4, 7; III, 4, near 6; V, 1, 3, 4; I, '04; and II, '04. These stations include a variety of conditions, balsam-spruce forests, tamarack and arbor vitae swamps; second growth of birch following a burn, and specimens were even taken in the Light-house. As there was some doubt as to the identity of certain specimens secured in 1904, the entire series of 55 specimens, including 46 taken in 1905, were sent to the Biological Survey and have been examined by Mr. W. H. Osgood who pronounced them *umbrinus?* [=*P. maniculatus* Wag. *cf.* N. A. Fauna, No. 28, p. 41, 1909.]

Ecological Notes.—Almost nothing is known of the life history of the variety *umbrinus;* it is only known from the vicinity of the northern shore of Lake Superior and Keewatin and the typical form *P. canadensis* fares but little better because the accounts of *P. leucopus* are confused with it. It seems safe to conclude, however, that it is a forest inhabiting species feeding upon seeds and nuts, but Preble ('02, p. 50) reports it as invading houses in Keewatin and as rare in swamps. It is also probable that they are active during the winter, at least on Isle Royale. The Beaked Hazel (*Corylus rostrata*) perhaps furnishes them part of their winter food.

Geographic Range.—Known elsewhere only from Peninsular Harbor (types), and Nipigon, Ontario. Compared with the typical form this is a dwarf and melanic variety. A similar dwarfing and darkening of this species occurs upon Roan Mt., N. C., and upon the mountains of southwestern Penn. (var. *nubiterrae*). A third variety, *abietorum,* occurs in Nova Scotia. The typical form of the species ranges from New Brunswick, western Massachusetts and central New York to northern Michigan and the north shore of Lake Superior, in Ontario.

5. *Evotomys gapperi* (Vigors). Red-backed Mouse. Although our parties trapped extensively in the vicinity of our camps, during 1904 and 1905, yet no specimens of this mouse were secured. The authority for its occurrence upon the island is the 10 recorded specimens (Nos. 7725, 9966 to 9974) given by Coues ('77, p. 145) and collected by B. A. Hoopes. These mice were "excessively abundant and universally distributed" on the shore of Lake Superior according to Miller ('97, p. 15). It is therefore surprising that is was not secured in abundance on Isle Royale. Michael Hollinger described to Max M. Peet a mouse which the house cat had caught during the winter and brought to the Club House. There were two of these specimens, which were described as reddish brown, short tailed mice, and which Hollinger said were quite differ-

ent from the White-footed mice with which he was familiar. It seems probable that these were Red-backed mice.

Ecological Notes. Very little seems to be known concerning the breeding habits of this mouse. Merriam ('86, p. 272) reports that in the Adirondacks he has examined females taken during April which contained four young, and one taken early in June was nursing her second brood; still later in the season, on October 4, a female was taken containing 4 young. Kennicott ('58, p. 90) found in Minnesota a nest with 8 young, and another litter of 5 or 6. He also states of the nests that "with the exception of one placed in a stump, they were all situated on the top of the ground, under logs. They were slightly formed of a small quantity of soft leaves and grass." Their food, according to Merriam, consists of seeds, berries, roots, and the bark of trees and shrubs. In addition to these materials Rhoads ('03, p. 93) states that they feed upon the leaves and stems of many weeds and grasses, various nuts and even land snails. Upon Isle Royale both Beaked Hazel nuts and snails are abundant. Rhoads further states that during the winter it subsists "almost entirely on the leaves of the evergreen strawberry bush, *Euonymus americanus*, which grows abundantly in the cedar swamps and damp hemlock forests."

The habitat of this mouse is of special interest and has been described by Batchelder ('96, p. 192) as follows: "One may look for it with some confidence in almost any large tract of wet ground that retains its moisture through the summer, but is not subject to serious floods, and which bears a growth of woods sufficiently heavy to afford a dense shade, so that the ground beneath, and the roots of the trees, are covered with a deep carpet of sphagnum. If the older trees have been suffered to die a natural death, and their stumps and fallen trunks lie slowly rotting on the ground, half-concealed by the sphagnum, the chance of finding it is certainly not lessened. One of the most evident peculiarities of such a spot as this, in southern New England, is that the dense shade and the abundant evaporation maintain a temperature during the hottest summer weather that is far below that of the surrounding country. In these respects of coolness, moisture, and shade, there is a striking resemblance to the woods *Evotomys gapperi* inhabits in extreme northern New England and other parts of the Canadian zone."

Geographic Range.—The typical form of this species ranges northward from Massachusetts, New York, Pennsylvania, northern Michigan, through southern Canada, westward to the Rocky Mountains. Miller ('97, p. 15) reported it universally distributed on the north shore of Lake Superior, and Kennicott ('58, p. 90) states that he found Red-backed mice (perhaps *loringi*) the most numerous in Minnesota (near Breckinridge) in low, heavily timbered valleys, although they were common on higher ground. There are 5 recognized varieties of this species; one, *ochraeus*, is confined to the White Mts. of New Hampshire; a second, *rhoadsi*, is only known from New Jersey; a third, *loringi*, is found in "timbered valleys along the edge of the plains in Minnesota, and eastern North and South Dakota" (Elliot); the fourth, *galii*, is from the mountains of Colorado and Montana; and the fifth, *saturatus*, is from the mountains of north-eastern Oregon, Idaho and British Columbia.

The geographic and topographic isolation of these varieties is worthy of special notice. The occurrence of a local firm (*loringi*) of a forest inhabiting species, in the forested valleys upon the plains is of special interest in showing how topographic and geographic influences may favor isolation.

6. *Fiber zibethicus* (Linn.). Eastern Muskrat. No specimens were taken by our party in 1905, but two specimens were found in 1904, at Washington Harbor by Max M. Peet (I, '04); and early in the spring of 1905 Charles Preulx secured one specimen from the same place—the small island near the mouth of Washington Creek. A few additional locality records were secured this season. Victor Anderson, the trapper, reported muskrats abundant at Sumner Lake (III, 5), and numerous broken *Anodonta grandis footiana* Lea shells were found there by N. A. Wood. Similar broken shells of the same form—were also found by Wood at Sargent's Lake, while I found such shells abundant at the end of the McCargoe Cove trail (II, 4). John Anderson reported muskrat houses at Fish Island Bay and at Tobin Harbor during the fall of 1904. There is an abundance of *Anodonta* and *Lampsilis* upon the island, especially of the former, which occur upon sandy shores, such as are found near the head of Rock Harbor. It may be a question as to how much broken shells should be taken as evidence of the presence of Muskrats, but the trapper's statements of occurrence are in harmony with the evidence from the shells. Perhaps part of the damage to these should be credited to the Mink.

Mike Johnson, fisherman, reports that he has seen the Muskrat at Chippewa Harbor. Mr. J. N. Malone, Keeper of Menagerie Island Light, several years ago found a Muskrat in the cellar of the Lighthouse (X, 10), and caught two near the camp in Siskowit Bay (V, 3).

Ecological Notes.—The Muskrat is one of the most generally known of our native mammals but although much has been written of its habits, much more is yet to be learned. In several respects its habits are similar to those of the Beaver, although they are not at all closely related. Thus both are aquatic, burrowing, house-constructing animals with submerged entrances to their houses. Both have been reported (Morgan, '68, p. 138) to exhale under the ice, and after allowing the bubbles a moment's exposure, to reinhale them, and continue their journey under the ice. Such similiarities, if true, are very interesting because they illustrate the independent acquirement of similar traits along distant lines of descent; due apparently to the influence of similar environments.

The life history is about as follows, but apparently varies in different localities. Thus in Pennsylvania, the young, according to Rhoads, ('03, p. 105) are born "at all seasons." This statement seems remarkable as Kennicott ('57, p. 107) states that "from five to seven young—more or less—are produced in April or May," and Merriam ('86, p. 283) states that in the Adirondacks of New York "It brings forth from five to nine young at a birth, and is said to raise three litters in a season." Farther north in Saskatchewan (MacFarlane, '05, p. 738) reports that the females are said to begin breeding when about a year old and give birth to "but two litters the first, and three each succeeding season for a time." The number of young in each litter varies from 8

to 20. In British Columbia the females are said to have three litters each season and to successively diminish in fertility with each brood. The species thus appears to be more fertile in the northern part of its range.

The food of muskrats consists of grasses and water plants, and includes a wide range of vegetable food. In addition to this vegetable food, occasionally dead fish and mussels (*Unionidae*) are eaten in quantities, as is shown by the abundance of shells along the banks of streams and the margins of ponds and lakes. Such heaps of shells are generally credited to the Muskrat, but the Mink, as has been suggested, may share in this. Direct observations bearing upon this point are very desirable, but the usual nocturnal habits of the Muskrat doubtless account for the limited information on this subject. There is a surprisingly small amount of direct information, in the accessable literature, on the relation of Muskrats to the mussels. Thus Kennicott ('57 p. 106) states that "Collecting them [mussels] from the bottom, it carries them in its teeth to a log or stone, where, sitting, upon its haunches, and grasping them in the fore-paws, it opens the shells with the incisors as skillfully as it could be done with an oyster-knife." * * * "I have observed that those species with thin shells are more sought for, and have often found large specimens of *Unio plicatus* unopened among the piles of empty shells, the muskrat apparently considering them not worth the trouble of gnawing apart the valves at the back, in which manner the heavy shells are sometimes opened." The Muskrat, like the Beaver, does not hibernate in winter but leads an active life, which means that they require a food supply throughout the winter. This they are usually able to secure under the ice, where they may store a supply, or by eating their lodge (Merriam, '81, p. 277), but in exceptionally cold winters or during a dry season, their winter supply may be frozen up; under which circumstances they may be frozen in their winter quarters, or must search for food above ground.

Extensive burrows are made in the banks of streams or in the shores of the bodies of water which they frequent, and in these they usually rear their young, although the houses or lodges may also be so used, especially in swampy areas. These lodges are generally built in the fall for winter use, and are constructed of grass, roots, mud and sticks; within this is a chamber, reached by a submerged passageway, leading under the ice.

Drouth, disease, large owls, Mink and perhaps the Otter are the most prominent native enemies of muskrats.

The conditions which cause migration are of interest on account of their bearings upon the geographic range and isolation of muskrats. Severe cold may shut off their supply of submerged food and necessitate a migration during the winter; also during the summer a change of residence may be necessitated by drouth, especially of those species which inhabit shallow ponds. This no doubt in part explains the occurrence of those animals which are occasionally taken far from water. Such migrations will not only explain in part the transference of these animals from one drainage system to another, but also the populating of isolated bodies of water.

Geographic Range. An examination of the ranges of the five species

of described muskrats, as given in Elliot's recent Check List ('05, pp. 252-255), clearly shows that very little is known of the range of these common animals; and at the same time their somewhat anomalous geographic relations suggest that the interrelations of these species must be imperfectly understood. Similar relations are suggested by the data concerning *zibethicus,* of which there are five varieties in addition to the typical form. This latter form ranges from Labrador to the Gulf States and northward, east of the Rocky Mountains, to Keewatin. As to its occurrence in earlier geological deposits, muskrat remains have been found in the Pleistocene deposits of South Carolina, New Jersey and Pennsylvania.

The post-Glacial changes within the glaciated portion of their range presents an interesting problem. Thus starting with a poorly drained glacial topography, the inwash from the surrounding hills, the accumulation of vegetable and animal remains, the perfecting of drainage lines due to the down-cutting of outlets, and other effects of running water, would all tend to encroach upon the poorly drained areas and convert them into dry land habitats; while, at the same time, there would tend to be a corresponding increase of stream habitats to a certain degree. Such changes as these would begin on the surface first exposed by the retreat of the ice; and since the ice retreated in a northerly direction, the southern margin of this drift would first be exposed to the general processes of metamorphism (in the sense of Van Hise) in the zone of weathering (so far as the soil was concerned) and to erosion (so far as the topography was concerned); and as the retreat continued these processes would extend their range of influence northward, and thus give to the environment a definite dynamic trend.

Fortunately, direct observation clearly shows that the processes just outlined in a general way have been active on all the drift surface. In general, the drift first exposed is the most metamorphosed and eroded and the best drained, while those regions which were later exposed are less metamorphosed and eroded, and imperfectly drained.

This gives ground for the opinion that as the ice retreated to the north there has been a general extinction, from the south northward of the poorly drained habitats whose origin was due to the glacial topography. Perhaps a more definite statement of these effects, from the standpoint of processes, would be that the direction of extinction was a resultant, determined by the direction of the ice retreat and the lines along which the drainage later developed.

The above remarks on the dynamics and history of the muskrat environment are of special interest on account of their bearing upon two problems as follows: first, the probable post-Glacial migrations of their optimum environment, as it thus seems probable that there has been a post-Glacial northward migration of the most favorable habitat for the muskrat; and second, on account of its influence upon the habits of muskrats. The muskrat is essentially a burrowing animal, and this is perhaps an older habit than house building. It is therefore of interest to know that the muskrats of the southern range are primarily burrowers, rather than lodge builders. In the south, below the glacial lake area, they frequent the sea coast, coastal plains, and streams,

but find relatively few small bodies of water, which are so abundant farther north. Except along the coast, these habitats are generally or relatively isolated, in striking contrast with their relative proximity in the north. These southern muskrats as a rule especially those inhabiting streams do not construct houses, but live in burrows.

Turning now to the northern part of the muskrat's range, from Labrador to the Mackenzie basin and southward into the glacial lake belt—the most extensive lake and swamp area on earth,—muskrats are found in the greatest abundance and development. Here instead of the relative isolation, as in the more southern part of its range, it finds an almost continuous habitat, of considerable geographic extent, and it is in this area that they are lodge builders, in addition to being burrowers, especially those that live about the swampy margins of ponds and lakes. This general change of habits between northern (Minnesota) and southern (Ohio) muskrats was pointed out by the Herrick (cf. '91, pp. 15-18; or Herrick '92, p. 212).

It is thus seen that a close relation exists between the habits and the habitats of this animal; thus, whether or not they live in burrows or lodges, is determined, in part, by the local topography and geological history. Such observations show the need of detailed locality studies of animals, in which the interrelations of the habits and the environment will be given primary attention. From such investigations, it will in the future be possible to prepare maps showing the topographic and geographic distribution of habits, just as other characteristics of the North American mammals, such as color, dimensions, etc. have been carefully investigated and mapped. But so far as known to the writer, no particular attention has been given to this phase of geographic problems. The muskrat would furnish an excellent subject for such an investigation on account of its extensive range, abundance and evident response to its environment.

But before leaving this subject, attention should be directed to the fact that while the above remarks apply primarily to the Muskrat, yet they have a much more general bearing, and apply equally well not only to many animals, but also, it is probable, to the habitat relations of many plants.

7. *Lepus americanus* Erx. Hudson Bay Varying Hare. With the possible exception of the White-footed Mouse, the Hare is the most abundant mammal upon Isle Royale. In all 27 specimens were taken from the following localities: I, 2, 3, 6; II, 2; III, 4, 5; V, 3, 4; I. '04, VIII, '04 and V, '04. Evidence for their presence occurred at the following additional stations: I, 5; II, 3; IV, 5, 9; and VII, '04. It is thus seen that their distribution was quite general and their abundance was equally characteristic. Although frequently found in the forest there was an apparent preference for open areas. This was suggested by the well defined paths or runways seen in sphagnum swamps, in *Cladonia* openings and on the jack pine ridges. The shallow soil with its attendant rock openings combined to produce an extensive area of favorable habitats for them; supplementing this is an abundance of vegetable food and a relatively small number of carnivora.

Ecological Notes.—The food habits seem to be quite varied as shown

by the variety of trees and shrubs whose bark and twigs had been eaten. All such injury seen was attributed to hares, as it occurred close to the ground in places frequented by them. The most extensive injuries to vegetation were on the jack pine ridge (I, 5) where the smaller lower branches of the Jack Pines had been eaten off up to about three feet above the ground. The cut ends clearly showed that the branches had been bitten off. The young Wild Red Cherry (*Prunus pennsylvanica*) growing in the crevices of the lava were often cut back, the bark removed and stems killed by the injury; *Amelanchier* showed similar injury. Along the trail to McCargoe Cove (II) Rock Maple, aspens and alders were seen with the bark injured. Max M. Peet observed the bark eaten from birches and Ground Hemlock at Washington Harbor, and from apples at Siskowit Bay (near VIII, '04).

At dusk the Hares came out to feed in the clearing about our camp at Siskowit Bay (V, 3), and were quite tame, coming close up to the camp. On a small island in Siskowit Bay, about ½ mile west of camp they were exceedingly abundant at dusk in a small clearing at a fishing camp. They were also abundant at Washington Harbor, along the road from the Club House to the old mining camp—Wendigo—and in the clearings at Neutson's Resort (IV, 5).

A very young specimen was taken (IV, '04) Aug. 22, 1905. whose total length was 190 mm. This shows that young are born in August, and it perhaps represents the last brood of the season. The size of other young specimens (215 and 310 mm.) suggest that at least one brood has preceded the one just mentioned, although it is probable that the broods are not sharply defined.

A very interesting periodic variation in the fertility of the Varying Hare (*L. americanus macfarlani* Merr.) has been pointed out by MacFarlane ('05, p. 740) who says "A litter usually consists of three or four; but when on the 'periodic' increase, females are known to have as many as six, eight and even ten at a time, and then gradually return to three or four." This periodicity he also shows (l, c., pp. 691, 692, 710) is of fundamental ecological importance in the nature history of the fur bearing carnivores of the far north. The staple food of the Lynx is Hare, so that when the latter decline in fertility and abundance, the Lynxes, not only also become reduced in number but are even known to starve. The Marten and to a much less degree the Mink also seem to be influenced in a similar manner.

Dr. Merriam ('86, p. 306) thinks that in the Adirondack Mountains there may be two litters in a season, of from four to six, the former being the usual number. The first litter is born late in May.

Upon Isle Royale in addition to those mentioned, other possible enemies of hares, at least for the young, may be the weasels, and the hawks, owls and the Bald Eagle.

There is an interesting seasonal variation of habitat (Merriam, '86, p. 305), in the Adirondack Mountains of New York; during the summer they tend to frequent the coniferous forests, and in winter the swamps, alder and spruce thickets bordering lakes and beaver meadows.

Notes on Color Variation.—A series of 27 specimens was secured during July and August, the examination of which shows that there is a

considerable color variation. In order to understand the significance of this it is necessary to have a general idea of the nature of the seasonal color changes of the Varying Hare. These hares have a brown summer coat and in winter a white one; and from this seasonal change or variation is derived the name Varying Hare. The difference in color is due to a change of pelage which occurs in the spring and fall; as one coat is shed another of a different color, grows and replaces it, proving conclusively that the white color is not due to a bleaching of the summer coat as some have supposed. Unfortunately this subject has not been investigated in Michigan, so that we do not know the exact period in spring and fall at which these moults take place. It would be of value and of interest to know how the time of moulting varies in different parts of the State.

This moulting process has been studied in detail by Allen ('94), from whose paper the following outline of the laws of moulting are taken. The fall moult (l. c. p. 121) begins "with the feet and ears, the sides of the nose and front of the head, which often become radically changed before the body is much affected; while as regards the body, the change begins first at the base of the tail and extreme posterior part of the back, and at the ventral border of the sides of the body, working thence upward toward the median line of the back and from behind anteriorly; the crown of the head and a narrow median line over the shoulders and front part of the back being the parts last changed. In the spring the order of change *is exactly the reverse,* the moult beginning on the head and along the median line of the anterior half of the dorsal region, extending laterally and gradually to the ventral border of the sides of the body and posteriorly to the rump, and then later to the ears and down the limbs to the feet, which are the parts last affected, and which often remain but little changed till the head and body have pretty completely assumed the summer dress."

The Museum collection, however, contains a specimen of *L. americanus phaenotus* Allen (determined by E. W. Nelson) from Houghton, Mich., which shows that the early stages of the fall moult may begin late in October (No. 31806, Oct. 30, collector, W. H. Grant), as the nose, ears, legs and lower hind parts of the body, are well advanced with the white pelage. The hind legs are only slightly mottled with fulvous although the upper parts of the fore legs still retain a considerable amount of this color. The remainder of the body is in the brown or summer pelage. Two April specimens *Lepus americanus* Erx. (determined by E. W. Nelson) from Luzerne, Oscoda, Co., Mich., (No. 31396, 31397, collector, J. A. Parmalee) have the white winter coat, and the upper parts of the hind feet more mottled with fulvous than in the Houghton specimen, while the upper parts of the fore feet are much more fulvous. It is hoped that by calling attention to the fragmentary character of our knowledge of the moulting of the Michigan hares others may be induced to secure the spring and fall specimens needed to complete the history of this process in northern and southern Michigan.

With regard to the moulting of the Isle Royale hares, but little is known, but a few observations made by Max M. Peet are of interest. The following notes were made by him September 13, 1905, at Washington Harbor: A large Hare whose ears and the upper part of the

hind legs were conspicuously white crossed the Wendigo road (I, '04). Others were seen which had apparently not begun to change, even on the ears or feet. Two were shot which had much white on the ears. In general the adults appeared to change first. Other specimens were seen at close range with white patches on the legs, especially on the hind ones, while the ears were apparently unchanged.

From the above observations it seems probable that the Isle Royale hares begin their fall moult about the middle of September. This is somewhat earlier than might have been expected from the observations of Miller made at Peninsular Harbor, Ontario, on the north shore of Lake Superior. He reports ('97, p. 8) that one specimen was taken October 5, in which the white winter pelage had begun to appear upon the ears and buttocks while others secured "about two weeks later had nearly completed the moult." It seems likely that there may be a considerable amount of individual variation in the moulting process. This is very clearly shown by an examination of the upper sides of the hind legs in the series secured from Isle Royale.

Geographic Range.—The typical form of this hare has an extensive northward range from Labrador and New Brunswick westward through Ontario, north of Lake Superior; Isle Royale, Michigan; northwestward to Alaska and the tree limit on the north. In 1900 Miller (p. 117) reported that "The northern varying hare occupies the wooded portions of Labrador. Its southern limit is not definitely known; but the animal does not reach the northern border of the United States." The specimens found last season (1904) by the Museum party thus appear to be the first recorded from the United States. Miller ('97, p. 8) records it common on the north shore of Lake Superior and Preble ('02, p. 59) states that it is "quite generally distributed throughout the region between Lake Winnipeg and Hudson Bay."

A decayed hare was found, July 6, upon the beach in a cove south of the Light-house (I, 1). It was, of course, impossible to determine whether the specimen came from the immediate vicinity or had been washed in from a distance. The abundance of table refuse (orange rinds, chicken bones?, etc.) stranded at the head of this cove suggested that at least part of the material came from the open lake to the northeast. This inference is further supported by the fact that the lake currents, as mapped by Harrington, favor this interpretation. The occurrence of the dead hare is of interest in connection with the question of the direction of origin of the mammal fauna upon the island and its relation to lake currents and the lake drift.

8. *Lynx canadensis* Kerr. Canada Lynx. A lynx skull was picked up at the Ransom clearing (II, 1) at Rock Harbor; its fractured condition suggested that it had been killed by a trapper. Victor Anderson and son, John, secured 48 skins during the winter of 1903 and 1904. Most of these were from about three miles southeast of the head of Rock Harbor, in the vicinity of Lake Richie. Lynx tracks were seen abundantly on the jack pine ridge on the north side of Conglomerate Bay (I, 5), also along the trail to McCargoe Cove, from the top of the Greenstone Range to the end of the trail. William Garnish, of Ashland, Wis., was camping at McCargoe Cove and reported that lynx tracks were abundant in the clearings about the old mines. Tracks

were also observed on the top of the Greenstone Range near the head of Tobin Harbor (IV, 9). A few tracks were noticed in the small rock clearings in the forest along the trail from camp (V, 3) to Siskowit Lake (V, 4). Near this trail, at the margin of a tamarack swamp (V, 5), tracks were found upon hummocks, and in another swamp (V, 11) in the sedge zone. Such observations suggests that the Lynx roams about everywhere through the swamps and over the ridges. Several years ago, Mr. J. H. Malone secured two lynx near the outlet of Siskowit Lake.

I secured a lynx skull from a mummified body found hanging on a tree where it had been left by Chas. Preulx along the Desor trail (VII, '04) through the hardwoods. Charles Preulx, Keeper of the Washington Club, has for several years trapped lynx at the head of Washington Harbor. Most of the specimens have been taken along the Desor trail, not far from the Club House. He uses fish and Hare for bait. During the past summer he kept one alive in a cage for about a month, and then sent it alive to Duluth, Minn.

In September Max M. Peet often saw the remains of Hare along the Desor trail and the Wendigo road, evidently marking the place where a lynx had taken a meal. He saw two live lynx on the Wendigo road (I, '04) about September 15; and a few days previous to this Chas. Preulx also observed one here. Two were caught in Preulx's traps, at the beginning of the Desor trail, but escaped.

The Lynx apparently wanders about over much of the island and seems to frequent in particular the rocky ridges, at least the tracks were especially abundant in such places. The Hare and Red Squirrels furnish an abundance of food for them. Attention has already been called to the close correlation, noted by MacFarlane, between the abundance of Hare and Lynx in Canada.

Ecological Notes.—The life history of the Lynx, in outline, is as follows: the breeding season occurs in April and May; in June and July from two to five and occasionally six young are born in a partly blind condition. They are "about the size of a puppy" and are suckled for about two months (MacFarlane, '05, p. 692). Reference has elsewhere been made to their dependence upon Hares, and to their remarkable periodical fluctuations in abundance. In their native haunts the food, in addition to the Hares, consists of eggs, birds of various kinds, small mammals and young deer.

Geographic Range.—The Lynx has an extensive range, on the east from New Foundland; Maine; New York; Pennsylvania; Isle Royale, Mich.; Mackenzie Basin to Alaska, and northward nearly to the tree limit. At the extremes of its range this species becomes differentiated into two local forms, while the typical form has an extensive range in the intermediate territory. It has also been found in the Pleistocene deposits of Pennsylvania.

Miller ('97, p. 44) states that he has no authentic record of the Lynx for Ontario. On account of their abundance on Isle Royale this seems rather remarkable.

9. *Mustela americana* Turton. Eastern Marten. During the past season Chas. Preulx took eleven Martens along the Desor trail (III, '04) among the maples. Hollinger secured one near the creek (II, '04)

and another on the ridge north of Beaver Island. Fish were used as bait.

Ecological Notes.—The breeding season occurs but once a year, during February and March, and the young, 6 to 8 in a litter, are born blind. Their nests are made preferably in hollow trees, under logs, and in holes in the ground (MacFarlane, '05, p. 711), or by robbing a squirrel of its nest (Coues, '77, p. 95). Its food consists of mice, squirrels and rabbits, supplemented by other small animals such as birds and their eggs, frogs, toads, fish, etc.

This animal, as well as the Hare and Lynx, shows the same kind of periodical variation in abundance, and MacFarlane ('05, p. 710) brings forward the following interesting observations bearing on this subject: "In years of plenty the marten is very numerous throughout the entire northern forest region; but is not uniformly so at the same time in every section of country all over the immense territories covered by the Hudson's Bay Company's trading operations. When it is abundant or scarce, say in the northern and western departments, it will generally be found that there is an important and corresponding increase or decrease in the southern and Montreal departments. The natives maintain that lynxes and martens migrate from the north and west to the east and south, and that when they have attained their height in numbers for several reasons, the great bulk (no section is ever totally devoid of martens) of those who escape capture resume the return march until the next period of protracted migration. It must be admitted that many old fur traders have come to entertain similar views from their own personal experience and observation. I think the aforesaid twenty-five years' London sales statement adds strength to the migration theory, and is otherwise of some interest." The natives also maintain that there is a fluctuation in the birth rate corresponding to this periodical abundance. Such migratory tendencies as above mentioned could not help but have an important bearing upon the geographic range and the interbreeding opportunities of these animals.

Geographic Range.—The typical form of this species has a range from Labrador; Nova Scotia; Massachusetts; Northern Pennsylvania; Quebec; Ontario; Michigan, southern Keewatin; Saskatchewan; Alberta; south on the mountains into Colorado; Utah; northwestward into eastern Oregon; Washington and British Columbia; and eastward to Hudson Bay on the north (Rhoads, '02, p. 445). A second form, of this species *brumalis*, is restricted to the coast of Labrador; a third, *actuosa*, ranges north of latitude 55° to the tree limit, from western Labrador westward to the Rocky Mountains nearly to the U. S. boundary and westward to the Coast Ranges of British Columbia into Alaska; a fourth form *abietinoides*, is restricted to the interior of British Columbia, the Selkirk and Gold ranges; and a fifth *abieticola*, is only known from Saskatchewan. So much differentiation of the type seems rather remarkable when combined with the marked migratory tendencies of the species and suggests that these wanderings may not be as extensive as has been supposed or that these movements are quite local in character.

10. *Putorius vison* (Schreber). Northeastern Mink. Three specimens of mink were secured at Isle Royale. One was taken at camp

on Siskowit Bay (V, 1) where it was shot by N. A. Wood at the water's edge during the day time; the second specimen was caught in the fish house at Malone's fishing camp, just east of our camp on Siskowit Bay. A steel trap had been baited with a Herring by Frank Malone. The third specimen was taken by W. A. Maclean, at the west end of Grace Harbor.

Victor Anderson saw a Mink on July 16, on the mainland at Rock Harbor, about opposite Middle Island. He reported it as abundant on the north of the Isle, at Fish Island, during the winter of 1903 and 1904, and also reported it from Tobin Harbor. Charles Preulx secured 18 skins during the past winter at Washington Harbor, most of which came from the harbor at the Club House, but a few were found upon the neighboring ridges.

There can be but little doubt that this animal is of general distribution over the island in moist and wet places. To what degree broken, mussel shells (*Anodonta*) may be credited to the Muskrats alone is uncertain, as the Mink may share in this mischief.

Max M. Peet saw numerous mink tracks, Sept. 16, (II, '04) along a small stream, where mink had eaten a Grinnell's Water Thrush, Hermit Thrush, and a few days previously an Oven Bird.

An entry in the University Museum Catalogue records a specimen of mink (No. 3595) from Isle Royale, collected in 1868 by Dr. J. C. Gubbs, and presented to the Museum by Dr. A. E. Foote.

Ecological Notes.—The breeding season for mink occurs in February and March, at which time the males wander about a great deal; the young are born about six weeks later, or usually in April. The young, which are born blind, remain so for about five weeks. There are usually five or six young in a litter, but the number varies and there may be only three, and it is reported to be subject to a periodical increase similar to that of the Hare. When on the increase, there may be as many as 8, 10 or 12 in a litter (MacFarlane, '05, p. 714). In each litter one sex is said to predominate (Coues, '77, p. 182). In the fall the young begin to shift for themselves, as Minks live solitary lives, not in pairs, and may frequently be seen swimming about, presumably in search of new quarters, This tendency, with the wanderings by day and night of the males during the breeding season, combined with his promiscuous tendencies, must have a marked influence toward favoring interbreeding. The females reach their growth in about a year, but the males require about a year and a half, although they are somewhat smaller than the females. Their nests are formed in burrows, hollow logs, muskrat burrows or other cavities, and the female makes for the young a compact nest out of leaves, grass and straw, and lines it with her own fur.

The Mink is very fierce, and so courageous that it will not hesitate to attack animals larger than itself, such as hares, muskrats, etc. Its amphibious habits allow it to procure food from both the land and water: Thus snakes, frogs, mussels and fish are secured from the water by diving (Webster, '89, p. 176), while birds and their eggs, and mammals are found on land. In pursuit of its prey, Kennicott ('58, p. 103) says: "It follows the track by scent, like a dog."

Geographic Range.—This species has an extensive range over most of

North America. The typical form however, ranges from Labrador and the Arctic Sea, westward to the north shore of Lake Superior, Ontario, to the Rocky Mountains, Michigan, northern Pennsylvania and New York. In spite of its activity, four other forms have become more or less differentiated but their ranges are not well defined, *lacustris* occurs west of Hudson Bay, *energumenus* from Pacific Coast from British Columbia to Alaska, *ingens* from the Yukon Valley and *vulvivagus* from the Gulf States.

11. *Putorius cicognani* Bonap. Bonaparte's or Least Weasel. Only one specimen was secured, and this is a white skin taken by Michael Hollinger in the vicinity of the Club House, at the head of Washington Harbor, on December 31, 1904. (No. 33016).

Dr. Merriam ('96, p. 6) has called attention to the close correlation between the geographic range of the *cicognani* group of weasels and the field mice (*Microtus*), but upon Isle Royale these mice are apparently lacking; it is probable therefore that the White-footed mice form an important element in their food.

Ecological Notes.—Very little seems to be known of the breeding habits of this species. It is reported (Coues, '97, p. 109) to have three litters of young a year, with four or more, frequently five, in a litter. The nest, located in a depression in the ground or a hollow tree, is composed of dry vegetation. The female shows almost unlimited courage in the defense of her young. The food consists of small mammals, birds and eggs, and insects. As to its native habitat preferences, in the Adirondacks Merriam ('86, p. 54) says: "It inhabits all parts of the wilderness, being found along water-courses, in deep swamps, and on rocky ledges and mountain sides." Like the Mink, it tracks its prey by scent.

The seasonal color changes of this weasel are of special interest. Rhoads speaking of Pennsylvania weasels ('03, p. 172) says "Bonaparte's weasel always turns white in winter even in its most southern distribution, but the New York weasel [*P. noveboracensis*] in the transition and austral zones very rarely turns white, the winter pelage being merely paler than that of summer."

Geographic Range.—The typical form ranges over forested areas of Labrador; New England; New York; Pennsylvania, in the mountains; Ontario; Northern Michigan; Minnesota; Colorado; British Columbia and Southeastern Alaska. In 1896, Merriam said: "It probably occurs also in northern Michigan and Wisconsin." Merriam ('96, p. 12) recognizes two varieties: *richardsoni* ranging from British Columbia and the interior of Alaska to Hudson Bay, and *alascensis* from southern Alaska.

12. *Putorius noveboracensis* De Kay. New York Weasel or Ermine. Two specimens were secured; one a small pale brown skin and skull (No. 33015) on December 31, 1904, by Michael Hollinger, near the head of Washington Harbor, and the other a much larger white skin taken in January, 1905, (No. 33019). Both of these specimens are referred to this species with doubt by Dr. Merriam.

Ecological Notes.—The breeding season occurs in February or March, and the young are born in April and May. The number of young in a brood appears to vary greatly, from two to a dozen, although four to six is perhaps the average number (Coues, '77, p. 125, 134). In the

Adirondacks Merriam ('86, p. 60) says "from four to six young are commonly brought forth early in May." The female is smaller than the male.

The food of the weasel consists mainly of small mammals and birds, but even animals much larger than itself, as the ruffed grouse, cottontails, and, about settlements, chickens, fall to its share. Upon Isle Royale, in all probability, the Hares and Grouse come into this class. Its habit of climbing trees, while of great advantage to it, proves to be the opposite for birds. Like the Mink, it follows its prey by scent. Kennicott ('58, p. 106) was of the opinion that it preferred rocky, hilly and forested regions. The frequency with which it occupies the burrows of other animals suggests that it does not burrow with ease, although according to Kennicott, it burrows in the snow. It also lives a solitary life.

Reference has already been made to the two seasonal moults of this species as compared with the Least Weasel. This color change, as in the case of the Varying Hare and Red Squirrel, is due to a fall and spring shedding of the old pelage and to the growth of a new one. Winter specimens from the vicinity of Ann Arbor, Mich., vary in color from dark brown, through chocolate colored specimens, to white.; while specimens taken November 6 (No. 34139) and November 18 (No. 30019) are white excepting a suffusion of pale brown hairs along the mid-dorsal line, the former specimen having much more brown, especially on the head and neck.

Geographic Range.—Southern Maine; New York; Pennsylvania; New Jersey; south to North Carolina and west to Illinois; and north to Michigan. A southern variety, *notius,* occurs in North Carolina.

13. *Myotis subulatus* (Say). Say's Brown Bat. Only two specimens of this species were secured; one by means of a broom in the case of one which entered the Club House on the evening of August 23, 1905, and the other on September 4, was also taken in the house at Singer's resort near the mouth of Washington Harbor.

Ecological Notes.—The females usually give birth to two young (cf. Merriam, '86, p. 195). Some species of bats migrate southward from the northern part of their range (Rhoads, '03, p. 209, Howell, '08). This species has been known to enter abandoned houses in such vast numbers as to become an intolerable nuisance, nearly 10,000 having been killed in one house. (Smith, Ann. Rept. for 1861, pp. 407-409). They take flight not only at dusk but at nearly dawn, and their flight toward and over water has suggested that not only food but water is sought there.

Geographic Range.—Nova Scotia; Rupert House, Quebec; Ontario; Maine; Mass.; New York; Penn.; Md.; Va.; West Va.; Tennessee; Michigan; Indiana; Illinois; Missouri; Wisconsin; Minnesota; Colorado; Alberta. There is a variety of this species, *Keenii,* occurring in British Columbia.

14. *Myotis lucifugus* (Le Conte). Le Conte's Brown Bat. Nine specimens of this species were secured by Max M. Peet between August 23 and September 6, at Washington Harbor (I, '04). At dusk several were shot while flying over the Harbor.

A few bats were seen on wing, which perhaps belonged to this species,

as it was apparently the most abundant form, or to *M. subulatus*. The last bat seen on the wing by Peet was about Washington Harbor, September 15. A small dark colored bat was startled from a loose projecting rock on the face of the cliff on the jack pine ridge (I, 5). A few days later one was flushed at nearly the same place. A bat flew into the Light-house at Rock Harbor but was not secured. Bats were also seen at camp on Siskowit Bay (V, 3). One specimen was taken in 1904 by Peet at Washington Harbor.

Two specimens were received from Michael Hollinger, who secured them November 30, 1904, at the Club House (I, '04). These evidently hibernated in the cellar as they were found on wing in the house after a fire had been built in the cellar.

This species had previously been collected from Isle Royale by B. A. Hoops, No. 5319, U. S. Nat. Mus. (Allen, '93, p. 80). Allen also records three specimens from Grosse Isle, Mich., collected by Rev. C. Fox, (No. 5500, 5501, 5505 U. S. N. M.); another specimen (No. 5354) was taken by S. F. Baird on the Detroit River. Miller in his revision of the family *Vespertilionidae* (1897) examined no Michigan specimens of this species.

Ecological Notes.—On account of the difficulties in determining bats, their life histories are much confused. This species Todd found hibernating in the caves of Pennsylvania (Rhoads, '02, p. 208), and the November specimens show that it hibernates on Isle Royale.

Geographic Range. This bat has the most extensive geographic range of any of the mammals on Isle Royale. The typical form ranges from southern Alaska east of the Rocky Mountains throughout North America, yet in spite of its powers of locomotion, two local forms are known; *longicrus* ranges from Puget Sound and Wyoming south to northern Mexico and Lower California, and *alascensis* which is restricted to the northern British Columbia and the coast region of southern Alaska. The differentiation of these forms, in the case of a flying mammal, suggests that the mountains form to some degree a true barrier within the range of this species.

15. *Vespertilio fuscus* Beauv. Brown Bat. One specimen was taken at Washington Harbor (I, '04) on August 19.

Ecological Notes.—Fisher (Merriam, '86, p. 184) remarks that this species is the last to appear in the evening and that they are "particularly fond of fields well surrounded by trees." It is an abundant species about human habitations and hibernates.

Geographic Range.—The typical form of this species ranges from California over the United States except Florida, and northward into British Columbia and Ontario. There are eight forms of the species ranging over the West Indies and south into Guatemala and Costa Rica.

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